Engineering and Mining Journal

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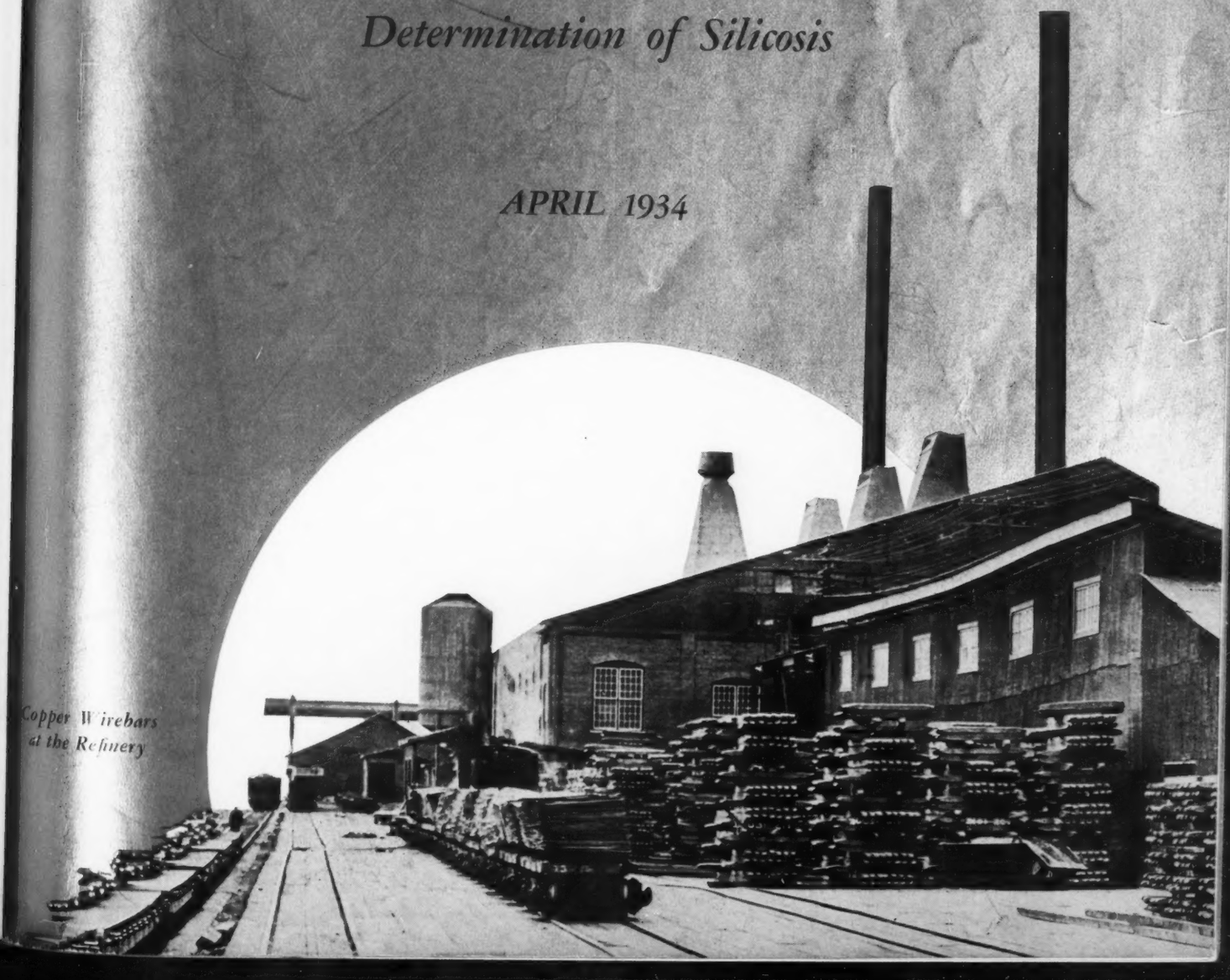
49

Transfer Scraper System on the Mesabi

Fundamentals of Flotation: Frothing Costs, Codes, and the Future

Determination of Silicosis

APRIL 1934



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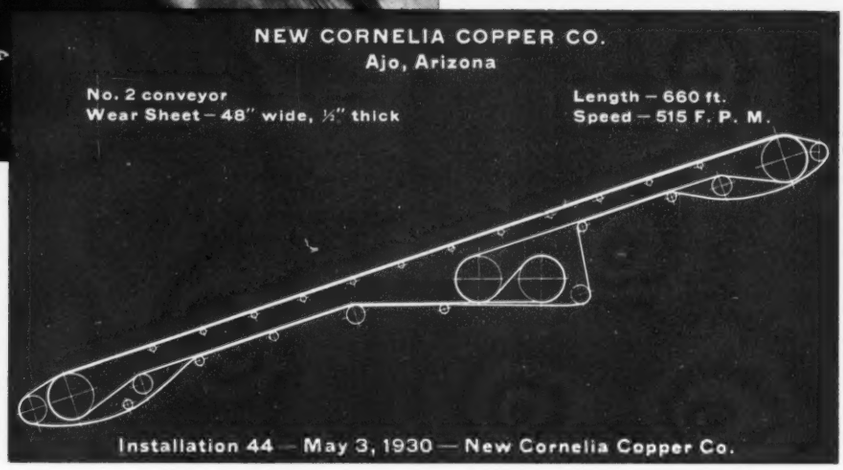
CLOSE-UP of head pulley, and extra idler pulley for wear sheet, at Duplex Belt Conveyor installation of New Cornelia Copper Company. Note the relatively small idler pulley made possible by the practically all-rubber construction of the wear sheet, and how the material is thus thrown clear of the conveyor in discharging.

INSTALLED four years ago, the Duplex Belt Conveyor here illustrated has given perfect service at all times, and the original wear sheet is still in good condition. Under normal operating conditions it conveys 4 in. to 10 in. copper ore from coarse crusher to intermediate crushing plant at the rate of 900 tons per hour.


NEW CORNELIA COPPER CO.
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Length – 660 ft.
Speed – 515 F. P. M.
Installation 44 — May 3, 1930 — New Cornelia Copper Co.

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The Duplex System, on the contrary, is economically sound because it comprises two separate units; a power belt traveling over the regular head and tail pulleys, transmitting all the power, and a wear sheet which rides on the power belt's back moved by frictional contact only—carrying all the load and absorbing all the wear. Operating records show that a Duplex Wear Sheet invariably gives longer service than the average old-type conveyor belt, while the Duplex Power Belt outlasts from three to four wear sheets—making a practically permanent installation.

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APRIL, 1934 VOL. 135—No. 4

Selection of Code Authority Now Copper Industry's Vital Problem

AGREEMENT has been reached on the terms of the Copper Code, according to NRA officials, who announced on March 28 that the document would be ready for the President's signature "in a few days." Following executive approval, the Code will become the law of the copper industry. Its conduct will thereafter be in the hands of a Code Authority created to administer and enforce the Code.

On the Code Authority, when selected, and on the spirit in which it discharges its duties, rests in large measure the future of the copper industry in the United States. If the Code Authority is capable and acts with wisdom, if it concerns itself with the spirit as well as the letter of the Code, the copper industry may expect a minimum of intrusion of "government in business." If, on the other hand, it fails to approach the solution of its admittedly difficult problems in a spirit of fairness and justice to all factors in the industry, and with due regard to the public interest, then and to that extent will it subject the industry to corrective supervision by the National Recovery Administrator and the Government. Despite the fact that the NIRA expires in June, 1935, we incline to the belief that thereafter some form of governmental control and regulation of industry will be continued, and that an effort will be made to retain permanently the demonstrated social and economic values that are inherent in the spirit of the Recovery Act.

Codes for the major metal industries should rank among the most important under NRA. In the first place, they deal with great natural resources, the conservation of which was part of the declared policy of Congress when it passed the Recovery Act; and second, the natural-resource industries are charged with a public interest that does not attach to many others. Metal code authorities therefore have a broad responsibility in protecting the public interest in natural resources and in planning for their industries a sound basis for recovery and future stability. Experience under NRA indicates that the best results of code administration have been obtained thus far by those industries that have the most capable, sincere, and earnest code authorities. The point seems worth double emphasis in the metal industries.

A Basis for Planning Under the NRA

WITHIN a short time codification of the major non-ferrous metal-mining industries may be logically expected. That development, long delayed by various factors, presupposes a certain amount of planning within those industries—planning broader in scope and of more social significance than any similar measures that may have been employed in the past. How shall such all-important procedure be drawn up and on what basis shall it be effectuated? The question, in its entirety, is undoubtedly unanswerable at this time, as recent discussions on the various codes have amply indicated. Nevertheless, a start toward the solution of this broad and complex problem is essential if these industries are to progress with others comprising the national economy.

In an effort to provide material that may be useful in reaching a planned status for the mining industries, *Engineering and Mining Journal*, beginning with this issue, presents a series of articles that will analyze these industries from the standpoint of production costs. An approach from this angle has seemed one of primary consideration, chiefly because of the wide variation in such costs among the members of the several industries, which circumstance code deliberations clearly disclosed.

The series of articles will consist largely of a number of tables prepared by the Minerals Division of the United States Bureau of Foreign and Domestic Commerce. These tabular data, based on statistical material readily available, are the result of a painstaking investigation, as any one familiar with such records will freely attest. The method employed in compiling the tables is, fittingly enough, one developed by a member of the mining profession, Mr. James R. Finlay, whose many contributions to the technical press on the subject of mining costs are well known.

Engineering and Mining Journal considers the opportunity to present this series of articles a decided privilege, particularly at this time, when plans for the con-

duct of industry in the near future are the subject of much discussion and are prompting such a wide variety of opinion. That the material will be found useful in building a new and better foundation for the metal-mining industries is the publication's sincere wish.

Annual Assessment Work On Mining Claims

EFFORTS made some years ago to bring about a revision of the United States mining law met with failure. Need for revision is still apparent, whether the problem be viewed in the light of past experience or of the New Deal. Were enthusiasts for the latter allowed to perform the operation, the result might be different from that wanted by some of those who in the past have argued for a change. Great stress would probably be placed on the public interest. If the natural-resource industries are in for some degree of regimentation and control, the program, to be thorough, might well include the procedure under which public mineral lands are allowed to pass into private ownership. For one thing, the Government might recapture those mining claims long held by locators who have made no real effort to develop them. Such recaptured land could be thrown open to relocation or else held in the public domain as a matter of conservation.

Mineral discovery has undoubtedly been retarded by the excessive liberality of the Federal law. The provision whereby the locator of a lode claim can hold it indefinitely, without attempting to patent it, merely by doing annually $100 worth of assessment work, was expressly written into the statute to encourage the prospecting and development of mineral land in the expectation of making new ore resources available to the nation. This generosity has been subject to abuse. Not only have many locators held their claims year after year without attempting to do more than the nominal amount of work prescribed, but often they can readily fake the performance of the required work, negligible as it is. A vast area in the aggregate has been tied up for years, and individuals and companies having the requisite financial means and an honest desire to search for ore have been thwarted.

What new discoveries might be made were this condition remedied can only be imagined. The Congress at Washington, as a further aid to the nation's recovery, could well prescribe a limit for the period during which a locator might retain his claim merely by doing assessment work. Care should be taken to prevent the same locator from relocating under another name. Thus, eventually, ground long tied up would either be developed or made available to others.

Until recently, Congress for more than a decade has limited its attention given the assessment work provision to suspending this requirement, through special enactment annually, as an aid to financially hard-pressed and deserving claim holders. (Unfortunately, the undeserving have also benefited.) About six weeks ago, however, the Senate passed a bill (S.2313) suspending the assessment-work requirement for the current fiscal year (ending at noon, July 1 next) in the United States and Alaska. Exemption is limited to individuals excused from paying an income tax and furthermore is not to apply to more than six mining claims held by the same person, nor to more than twelve held by the same partnership, association, or corporation. Thus, the Senate is looking in the right direction. The measure, however, leaves the situation unchanged respecting locators who will not comply with the assessment requirement if they can avoid it, or who will in no case attempt to do more than $100 worth of work on any claim.

The President, as Conciliator, Interprets Section 7(a)

FROM the time of its enactment last June, Section 7(a) of the National Industrial Recovery Act, with its mandatory provisions for employee representation and collective bargaining, has been regarded as a potential source of trouble to the Administration in its program for recovery. The law has been the subject of varying interpretations, by the National Labor Board and the National Recovery Administration, of the rights of employers and employees, organized labor unions and company unions, majorities and minorities. But in all official pronouncements the inevitable thread of "public interest" as the dominant factor has run through the fabric of interpretation, thus revealing the ultimate objective of the Administration. In the rugged language of General Johnson it is the Government's duty "to see that industry does not hornswoggle labor; that labor does not bullyrag industry; that neither, separately, nor both in concert, shall exploit the consuming public."

Nine months after enactment of NIRA the issue of Section 7(a) was joined in the automobile industry. Brought to a head by threat of a disastrous strike by the American Federation of Labor, there followed two weeks of conference between the Administration and representatives of manufacturers and union labor. Obviously committed to the execution of a law that had his approval, the President had to assume the rôle of conciliator and finally settle the matter. He is to be commended for inducing both sides to accept a compromise "in the public interest," and thus avoid an industrial dispute of far-reaching consequences.

The language of the President's official interpretation of Section 7(a) is encouraging. He recognizes the right of employees to organize in "a group or groups" with pro rata membership on bargaining committees. Through NRA he sets up an impartial board to deal decisively "on the basis of common sense and justice" with questions in controversy. He "favors no particular union or particular form of employee organization or representation." He seeks only "freedom of choice without coercion, restraint, or intimidation from any source." He reminds labor that "organizations of employees seeking to exercise their representative rights cannot at the same time be unmindful of their responsibilities."

In our judgment the President's conciliation is the right approach toward better industrial relations—conference and compromise versus strife and a test of strength. More steps of like character are needed. They are far more likely to evolve gradually a sound policy of industrial relations than will be achieved by legislative fiat through the Wagner bill or any other form of new and unfamiliar prohibition that is suddenly forced on the country.

Labor is entitled to organization. But a monopoly in labor control is just as unwelcome a form of dictatorship as is one of capital control. Organized industry is being brought more and more under Federal regulation through NRA and other agencies, and organized labor cannot escape the same treatment—even to a denial of its right to strike—if in its reach for power it begins to assume monopolistic tendencies. Who, then, shall be the arbiter? Perhaps, in the rapidly shifting American scene, we are approaching the time when the Government alone will settle these matters. Who knows?

Mining Industry Maligned

On Safety Score

ENGINEERING AND MINING JOURNAL cannot keep silent when a grave charge is wrongly made against the American mining industry, as recently happened at the first public hearing in Washington on the then proposed NRA code for the copper industry. On this occasion, in testifying before the Deputy Administrator, one Thomas Brown, a miner of Butte, Mont., and allegedly a spokesman for a miner's union, painted a dark picture of the average conditions under which "deep-level miners" work in the United States. If what he said is true, these miners work in distressing and unsafe conditions, and every mine in the country should indeed be closed (as another witness declared) until the hazards to life and health be mitigated. If his description merely approaches the truth, one may properly ask where the National Safety Council has been all these years and what has been done with the millions of dollars spent by mining companies on safety work. Also one may inquire why the mine inspectors of the various states have allowed such wretched practices to continue. The United States Bureau of Mines has long devoted its best efforts to developing safe mining practice and spreading the gospel of safety. Let the Recovery Administration seek its testimony, if such testimony be necessary.

The Bureau need not go on the stand, however. The accident rates of the individual companies and of the industry as a whole speak for themselves. Conditions such as described by Mr. Brown would inevitably cause these rates to be unusually high. The excellent record of the industry bears witness to the falseness of the charges. This point was made at the hearing by a representative of the principal operator of Butte, a company which has spent many millions in the last fifteen years with great success on the improvement of air and temperature conditions alone in its underground workings.

All this is not to say that mining does not have its risks for health and life. Of its very nature it offers hazards which can never be wholly removed. Nor does it mean that problems of ventilation and ground support do not at times baffle skilled engineers, or even that laxity of supervision and failure of the human element do not occasionally subject workmen to unnecessary risk and hardship. Such unusual instances, however, are not to be taken as representative of average conditions.

Non-Ferrous Metal Statistics

Point to Trade Expansion

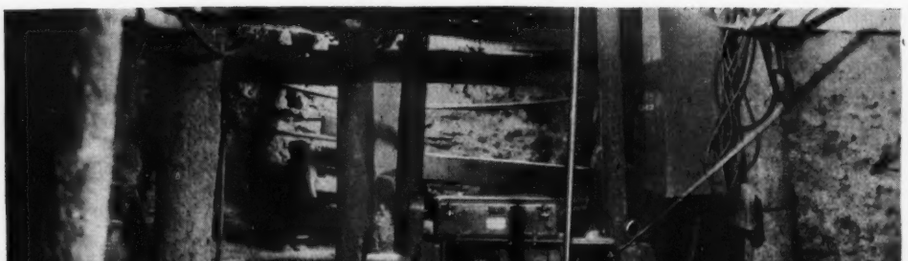
BUSINESS INDICATORS continue to record gains, notwithstanding the almost daily changes in the world's political and economic set-up. Not a few observers regard the obvious improvement in the movement of commodities and manufactured goods as a natural turn in the business cycle. Non-ferrous metals, shipments to consumers show, have shared in the general expansion in trade.

Copper, measured statistically—without taking available statistics too seriously—is convalescing. Stocks of refined copper in the hands of members of the Copper Institute on March 1 were unofficially reported at 612,000 tons, against slightly more than 630,000 tons a month previous. A year ago the stocks held by the group that accounts for 90 per cent of the world's production were estimated at 750,000 tons. In the twelve months' period the improvement in the position of copper has been substantial. Though the low prices have been a real hardship for producers, the unremunerative market served the good purpose of controlling output. Signs are not lacking that the power industry is now fully conscious of the necessity for aggressive action to expand consumption of electricity. A modest recovery in the demand for copper by the utilities could easily swell monthly deliveries of the metal to more than 40,000 tons. February deliveries of copper in the United States amounted to 37,000 tons, which compares with 32,000 tons in January, and 25,000 tons in December. Average monthly deliveries of 40,000 tons or more would greatly strengthen the price of copper in this country.

Refined lead stocks in the United States increased to the record high of 216,000 tons during February, an unfavorable development when viewed alone. Actual consumption of lead is again tending upward, and, with producers taking steps to hold output in check, lower prices hardly seem probable. In lead circles it is pointed out that total stocks of lead, including lead in ore and in process, show only a slight gain.

High Grade zinc has been doing well, largely because of the activity in the automobile industry, where so many accessories are now made of die-cast zinc. Prime Western zinc is still awaiting a resumption of buying of galvanized products in the agricultural sections of the country. Government aid to farmers is expected to have more than a little influence in reviving this market.

The statistical position of major non-ferrous metals, weighing all the evidence in hand, should improve over the second quarter of the year.



Automatic transfer tugger or scraper hoist used at chute end of transfer drift

Transfer Scraper System

Improves Efficiency at Underground Iron Mines

ON MESABI RANGE

IN AN EFFORT to improve efficiencies at its underground iron mines, time studies were made by Pickands, Mather & Company on all phases of the slicing operation at the Bennett mine at Keewatin, Minn., on the Mesabi Range. At this property small feeder tugger hoists were in use, to load ore from slices into sublevel cars that were trammed by hand to the chute. Loading and tramming, which consumed about 30 per cent of the time for a complete slicing cycle, offered the greatest possibilities for improvement. At first, changes were made in the sublevel car to good advantage. The transfer tugger system in the slices was later developed to still greater advantage. This development will be described in this article.

A 60-cu.ft. sublevel car was in use when the first time studies were made in slicing. This car was of the end-dump type and had a wood box to reduce its weight. It was built low, so that the slides under which it ran would not have to be very high. A wheel base of 15½ in., with 14-in. flanged wheels, was the shortest possible under the conditions at this mine. By stepping on a lever, the miner could apply the brakes to stop the car at the chute.

A track grade between 0.75 and 1.00 per cent in the transfer drift was the most efficient for this car. Over it one man could push the loaded car to the chute and return the empty. To ease the starting, when loaded, the rails under the slide were raised to a steeper grade.

In working places during this test two miners constituted a crew, and in a complete cycle they took out on an average approximately a 50-ft. slice. A standard 10-ft. cap was used. For comparative purposes, a 12-ft. mining height with a 200-ft. transfer drift will be used.

Beginning a Slice

To begin a slice, the back of the transfer drift was raised to the top of the ore, with either surface or cave in the back, and open sets were placed in the drift. A slide was built in the drift as near the working place as possible. Its slope was about 35 deg., and the floor was made as high above the top of the car as the back would allow, to permit efficient loading. A 6½- or 10-hp. tugger was set on the slide, and from this position, using a standard 42-in. scraper of about 10-cu.ft. capacity, the ore was loaded from the open sets and from the first cuts on either side of the drift. Then the slide was erected on one side of the open sets and, on the opposite side, a platform was built for the tugger. The slide floor was about 8 in. above the car, so that 6-in. boards could be placed on the two sides to prevent spillage.

With 6-in. boards on the 60-cu.ft. car, an average load of 67 cu.ft. was obtained. For a 50-ft. slice, the average time required for scraping with the small feeder tugger was 4.9 min. per car. The miscellaneous time (trimming the breast, shovelling the bottom for timber, and rope breakage) was 4.5 min. per car. Scraping and miscellaneous together made 9.4 min. per car, which was fairly constant for all slices under time studies. The time for hand tramming varied with the drift length. In a 100-ft. drift the hauling and returning required 1.2 min. per car, including acceleration for starting and

stopping. For every additional 100 ft. of length, the time was 0.8 min. per car. Total time to load and tram the 67-cu.ft. car in a 200-ft. transfer drift was 11.4 min.

Miners' production was measured by the number of main-level cars taken out of the chute. These were of 55-cu.ft. capacity. A curve was desired for purposes of comparison, to show the total tramming time per 55-cu.ft. car. To plot the 67-cu.ft. sublevel car time on the Time Per Car Curve, the 11.4 min. in the 200-ft. drift, when converted to the 55-cu.ft. unit, equals 9.4 min. per car (point on curve). This is shown in Fig. 1.

With the 60-cu.ft. car in a 200-ft. transfer drift and a 12-ft. mining height, a production of 24.5 tons per miner per 8-hr. shift was obtained.

With two miners working in one slice, blasts were often made during working hours, causing considerable delay in blowing smoke. To eliminate these time losses, three miners were given two adjacent places to work; that is, slicing off two transfer drifts. When smoke was being blown in one place, the miners worked in the other. Production showed an increase as compared with the two-man contract.

To decrease the number of trips made to the chute, a larger sublevel car was built. It was of 90-cu.ft. capacity, or about 5 tons, and was handled by one man in tramming, but the track grade had to be set carefully. The car showed some advantage in production as compared with the 60-cu.ft. car.

Transfer Tugger Installed

When miners were tramming, one was idle while the other loaded the car, and the tugger operator was frequently idle while the car was going to the chute. To eliminate these losses, and also the time for building the slide and moving feeder tuggers in the transfer drift when raising for open sets, a large transfer tugger was placed at the chute to move the ore from the feeder tuggers.

In the experimental stage of the development of this transfer tugger system, two miners took a single slice off an 80-ft. transfer drift with a 20-hp. transfer tugger at the chute. A 42-in. scraper of about 20-cu.ft. capacity was used in scraping over the rails of the sublevel car track. When the open sets were placed, the feeder tugger was rigged on one side and a slide was built on the other, above the transfer tugger ropes. The scraper soon filled in the tracks to the top of the rails, and scraping was continued over a broken ore bottom. This did not prove satisfactory, inasmuch as the average scraper load was only 10 cu.ft. per pass, at the completion of the slice. Nevertheless, with the transfer system a tonnage per miner of 27.0 was attained, compared with 24.8 tons when the 60-cu.ft. sublevel car was used in the same place.

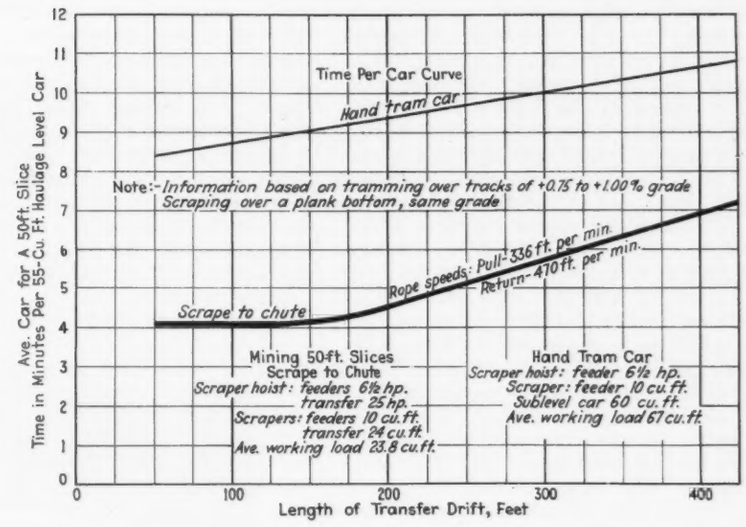
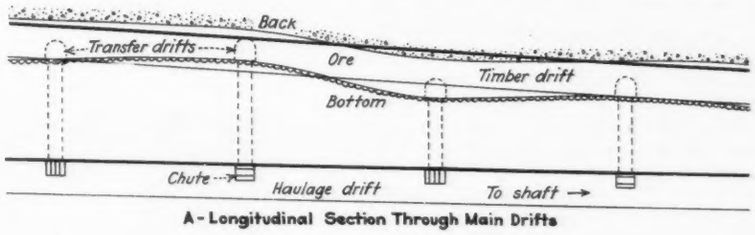
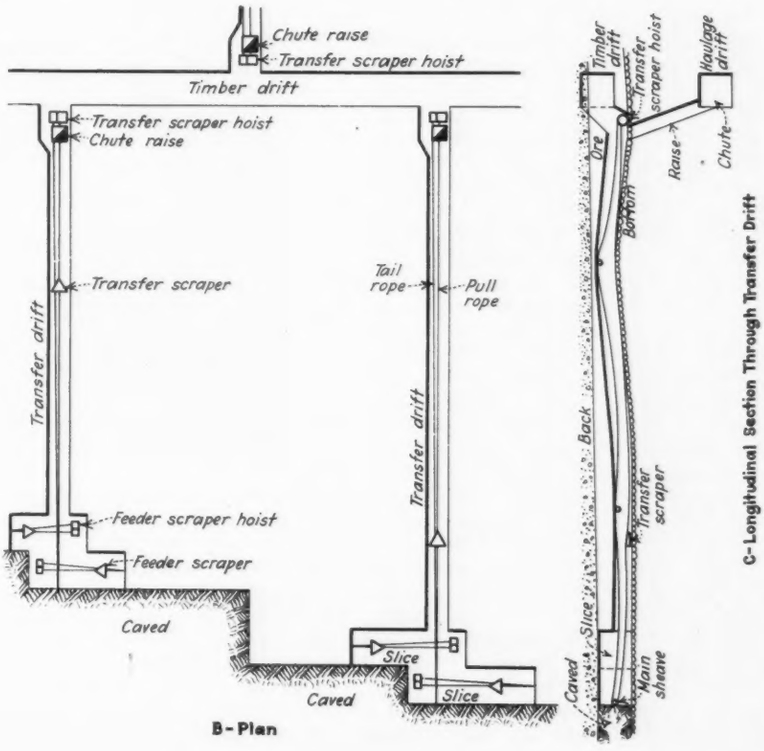

Time Per Car Curve
Hand tram car
Note:-Information based on tramming over tracks of +0.7% to +1.00% grade
Scraping over a plank bottom, same grade
Rope speeds: Pull-336 ft. per min.
Return-410 ft. per min.
Scrape to chute
Mining 50-ft. Slices
Scrape to Chute
Scraper hoist: feeders 6½ hp.
transfer 25 hp.
Scrapers: feeders 10 cu.ft.
transfer 24 cu.ft.
Ave. working load 23.8 cu.ft.
Hand Tram Car
Scraper hoist: feeder 6½ hp.
Scraper: feeder 10 cu.ft.
Sublevel car 60 cu.ft.
Ave. working load 67 cu.ft.
Ave. Car for A 50-ft. Slice
Time in Minutes Per 55-Cu. Ft. Haulage Level Car
Length of Transfer Drift, Feet

Fig. 1—Time Per Car curve

Fig. 2—Plan and sections illustrating diagrammatically the method of operating with the transfer-tugger system for moving ore from stope to chute under the slicing method of mining



A-Longitudinal Section Through Main Drifts



B-Plan

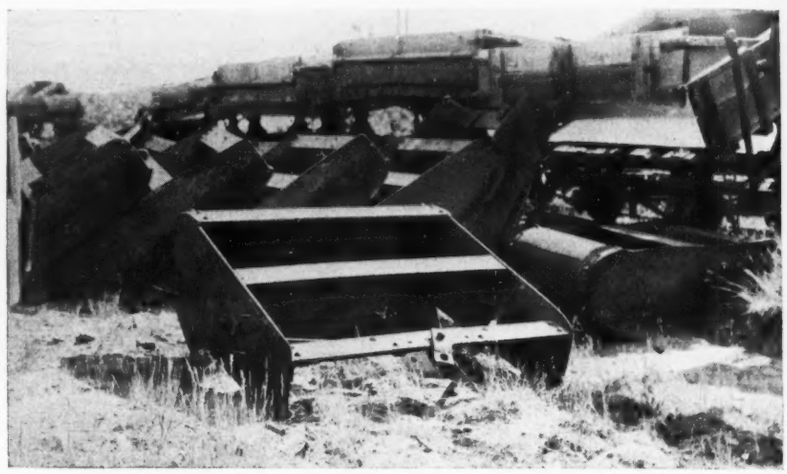
C-Longitudinal Section Through Transfer Drift

The transfer system, as developed thus far, had decreased the percentage of time required for tramming, so a plan was next adopted for increasing the amount of ore to be moved at this faster rate. This was accomplished in the second trial by mining two opposite slices together. These were staggered on either side of the transfer drift so that one feeder tugger on the left side of an open set operated in the opposite direction to another tugger on the right side of the adjacent open set. This is shown in Fig. 2. This operation was carried on by three miners with a 20-hp. transfer tugger in a 150-ft. drift. The feeder tuggers were rigged on platforms about 4 ft. high to keep their ropes above those of the transfer tugger; all slides were completely eliminated. The bottom of the drift for a width of about 4 ft. was covered with 1½-in. hardwood planks from the chute to the slices. In scraping over the planks the load of the transfer scraper was increased to 17.0 cu.ft. per pass from the 10 cu.ft. attained without planks. At the chute was a sharp incline or slide, which was built to increase the chute capacity. This system showed a production of 30.8 tons per miner, as compared with 27.0 tons with the 60-cu.ft. car in the same place.

With three miners working two slices, it was possible to confine most of the smoke blowing to lunch or quitting time. Another advantage was that less aid was required from timber men, as no slides were needed and if timbering was too heavy for two miners, the third could help.

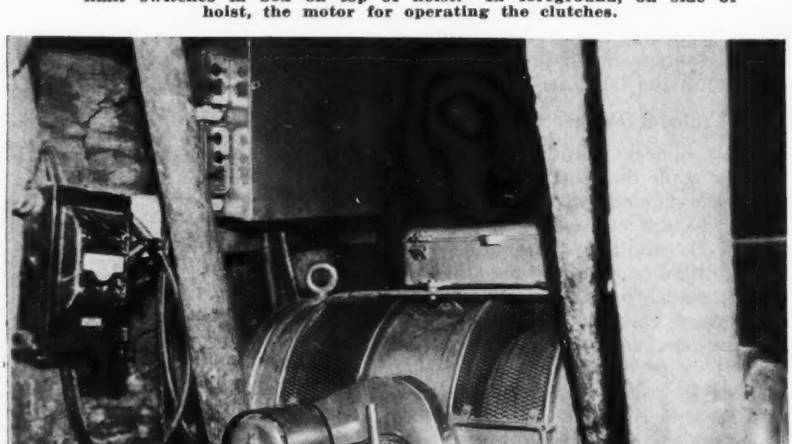
Thus far the scraper system had been operated in short drifts where the miner at the transfer tugger could see the scraper loading at the slices. To try the system in a long drift where the chute-tugger operator could not see the scraper at all times, a transfer drift 280 ft. long was chosen. Two miners were employed while raising was being done for open sets, and three miners completed the two slices after the feeder tuggers were set in place. A 25-hp. transfer tugger, with speeds of 336 and 470 cu.ft. per minute respectively, was placed at the chute. In this long drift the tugger operator could tell by the feel of the machine when the scraper struck the snatch block. This impact caused considerable strain on the return cable, however, so a spotting system had to be devised. At first, markers on the pull rope were tried, with little success, because wire or white-lead markers moved or wore off. Then signal lights were placed at the chute and at the slices with switches near each feeder tugger. If the transfer scraper did not fill well at the first loading, a miner inside would signal for another loading, thus eliminating the delays of working with partly loaded scrapers. With a scraper 48 in. wide and of 24-cu.ft. capacity (level full), an average working load of 23.8 cu.ft. per pass was attained for the complete operation. The power required to move the scraper at various stages was as follows: Returning empty scraper, 8 hp.; loading start, 48 hp. (peak); and pulling loaded scraper, 24 hp. This operation proved the transfer system to be satisfactory, inasmuch as a figure of 26.0 tons per miner was attained with three miners in two slices of a 280-ft. drift with a 10-ft. mining height. With the 60-cu.ft. car, two miners of the same crew produced 22.5 tons per miner in one slice of 11 ft. height and a 325-ft. drift. With a 200-ft. transfer drift and a 12-ft. mining height, the scraper system gave an average of 30.7 tons per miner, which represents an increase of about 25 per cent over the 24.5 tons per miner attained with the sublevel car.

To be able to set miner's rates at different mining heights and lengths of transfer drifts, curves were made to show what tonnage per miner to expect under any condition. Knowing the speeds of scraping and tramming with the sublevel car, the Time Per Car Curve (Fig. 1) was plotted as mentioned in the foregoing. From the various places where studies of the transfer system were made, an average miscellaneous time per car of 2.0 min. was found to be constant. This included time for stops made by the transfer tugger while the operator helped the miners in the slices, as when trimming sides for timber, or when the rope broke. With rope speeds of 336 and 470 ft. per minute, and an allowance of 5 sec. per pass for retardation in loading, the time required for transfer scraping in a 200-ft. drift was 2.6 min. per 55-cu.ft. car. The total time per car for miscellaneous and scraping equals 4.6 min. (point on curve). In a similar manner the curve was plotted for



Box-type scraper, 24-cu.ft. capacity, used in transfer system

Another view of automatic transfer scraper hoist. Main line switch at extreme left. Relays and contactors in upper left center. Geared limit switches in box on top of hoist. In foreground, on side of hoist, the motor for operating the clutches.



all but the short drifts. As the length of the drift decreases to about 150 ft., the curve flattens, because the transfer tugger cannot scrape any faster than the slice tuggers can feed it. The average time for the two feeders to scrape a car of ore into the drift from a 50-ft. slice was 2.1 min. With this added to the miscellaneous time of 2.0 min., the minimum average time was 4.1 min. per car. Using the Time Per Car Curve and knowing what tonnage per miner to expect from time studies at certain mining heights and lengths of drifts, the production under all conditions could be figured. Ore structure has a definite bearing on the efficiency of any system of tuggers and scrapers.

Labor Cost Per Ton

By dividing the miner's rate per day by the "tons per miner" for the average mining height and transfer drift of a mine, a very close estimate may be made of the miner's labor cost per ton of ore. The power consumption figured about 0.524 kw.-hr. per ton, with a transfer drift of an average length of 300 ft. Two-inch plank on the bottom of the transfer drifts proved most economical. Cost of material and labor for the planking varied with the length and irregularity of the drift. Broken ropes of the transfer tuggers were salvaged wherever possible for use on the feeder tuggers.

The Utica Extension mine was thereupon developed for the scraper system of slicing. Transfer drifts, of an average length of about 340 ft., were driven straight from the chutes to the boundaries of the blocks to be mined and along the bottom of the ore, regardless of contours (see Figs. 2B and C). In driving these 6x6-ft. drifts comparatively high production was shown, for no slides had to be built, as when the sublevel car system was used. The plus and minus grades of the bottom made no appreciable difference in the scraping time. The transfer tuggers at the chutes varied from 20 to 35 hp. with pull-rope speeds of 220 to 450 ft. per minute and tail-rope speeds of 220 to 550 ft. per minute. Feeder tuggers varied from 7½ to 15 hp.

Many of the older tuggers used as feeders were equipped with d.c. motors, but all of the large transfer tuggers and new feeder tuggers were equipped with 440-volt a.c. motors. The a.c. power was distributed through the main drifts by four-conductor combination cables having three insulated power conductors and one bare ground conductor. The outside jacket consisted of a treated fabric suitable for underground service. The cable was suspended on hooks attached to the timber. Taps were made at intervals and connections provided to fused switches for each tugger. Power was carried from the switches to the tugger by six-conductor combination rubber-covered cables, having three power conductors and three bar ground conductors. Nonfusible switches were provided at the motor to be used in starting and stopping the machine. A continuous ground wire was carried throughout.

Box-type scrapers were used in slicing throughout the mine. The depth of the transfer scraper tapered from 2½ ft. at the blade to one-half that depth at the bale. Similarly, the feeder scrapers tapered from 1½ ft. at the blade. Of the 48- and 60-in. width scrapers used in the transfer drifts, the former had a better loading efficiency. The 48-in. scraper of 24-cu.ft. capacity maintained a working load of 29 cu.ft. by sliding ore ahead of the bale. A standard feeder scraper of 42-in. width and about 10-cu.ft. capacity gave satisfactory results. A larger feeder of the same width, but built up to about 14-cu.ft. capacity, was tried. In a large volume of ore it scraped faster, but it could not get around the timber or as near the breast as the standard feeder. The gain in scraping time was offset by the extra time required for picking and in shoveling the corners.

The ½-in. pull and ⅜-in. tail ropes gave satisfactory service. To prevent excessive wear of the latter in dragging over the drift and scraper, 6-in. supporting sheaves were hung at intervals along the drift. An 8-in. sheave was used at the drift end where the greatest bending stresses occurred in the tail rope.

Rope Attachment Difficulties

Difficulties were had at first in attaching ropes to scrapers. The clevis and knotted end would not hold on the large scrapers as they did on the feeders. The rope looped around a thimble and the end fastened with cable clamps made a secure attachment for the 48-in. scraper. This thimble was a narrow plate bent like a horseshoe at about a 2½-in. diameter and grooved to fit the rope. A half hitch in the dead end around the live rope between cable clamps was used to hold the 60-in. scraper.

A new phase of the scraper system was evolved at the Utica Extension in the development of the automatic transfer tugger. A 35-hp. tugger was set at the chute, which automatically did all the transfer scraping. With the proper adjustment made for the length of the drift, the machine could return the empty scraper to the sheave, reverse itself, pull to the chute, and return again with no more attention from the miner than the initial starting. Control switch buttons were conveniently set near the feeder tuggers. By pressing them, the miner could start, stop, or reverse the scraper at any stage of scraping. Speeds were 450 and 550 ft. per minute on the pull and tail ropes respectively. At a distance of 25 ft. from the working place and the chute, the speeds were automatically reduced in both pulling and returning. This slow speed made better loading possible and was also a good safety measure. Retardation distance was adjustable at the tugger.

The pull and return operations of the scraper were controlled by a traveling nut-type limit switch mounted on top of the tugger. This switch was driven through a chain by a pinion geared to the pull drum. Reversing was accomplished by a small-torque motor that engaged the clutch on either the pull or return drum, dependent on its rotation. To reduce the possibility of damage from over-travel in the return direction, especially with the small working clearance at the tail sheave, a resistor was inserted in the torque motor circuit. This resistor could be adjusted to limit the maximum pull of the return rope to any desired amount. An emergency control at the chute was provided by means of a rod-operated switch hanging at a point beyond the normal travel of the scraper. In case of irregular or bunched winding on the pull drum, the scraper would knock the rod and shut off the power before it could run into the tugger. Inasmuch as the limit switch is merely a revolution counter, allowing the cycle to alternate within a given number of revolutions of the pull drum, some trouble was caused by the variations in travel at the chute end, due to overwinding. A better arrangement would be a double limit switch to control each travel in the unwound position of its respective drum. Delays caused by the use of the emergency switch were reduced to some extent by lengthening the mouth of the chute along the drift, to give more leeway for overwinding.

That the automatic tugger was a labor saver was demonstrated by the fact that one miner alone could control the transfer scraping and scrape with a feeder in one slice, while the other two miners were drilling or timbering in the opposite slice. With the three miners in two slices, 23.7 tons per miner was obtained, compared with 21.2 tons per miner achieved with a hand-operated transfer tugger under similar conditions. Also, under the same mining conditions, two miners in one slice with the automatic tugger showed a production of 25.3 tons per miner.

Advantages

The advantages of the transfer tugger over the sublevel car are great enough to warrant the planning of a mine for the transfer system. A decided saving can be made over car tramming by making the transfer drifts 300 ft. or less in length, although at 400 ft. the system may still be advantageous.

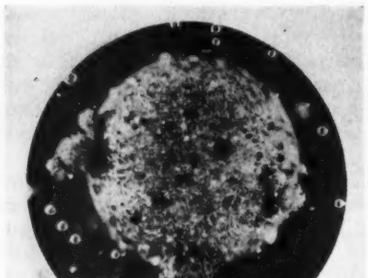
The transfer tugger system is applicable to orebodies of varying thickness, but has a special application to thin orebodies, in which the scrapers follow plus and minus grades without difficulty. Note Fig. 2C. In such places the use of the hand tram cars would necessitate considerable costly rock work for the development and mining of the orebody.

FUNDAMENTALS OF FLOTATION

In the Light of Recent Research

FROTHING

The first of a series of four articles. The second will deal with collecting in flotation, and the third and fourth with conditioning.



Photomicrograph of an armored bubble

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FROTHING is the most conspicuous of the elementary phenomena comprising the flotation operation. It is also one of the essential factors of the process, for without it no overflow could be obtained and therefore no concentration could be effected. The mechanism of frothing is purely physical and is based primarily upon one of the properties of liquids—namely, surface tension.

When gas which is relatively insoluble in a liquid is bubbled through it and forms a column of substantially persistent bubbles, we have a froth. The collection of bubbles constitutes the froth. If the bubbles had no durability, they would burst on reaching the surface of the liquid. In frothing, the persistence of bubbles is therefore of vital importance.

Bubbles are holes in a liquid filled with gas. The persistence of bubbles depends upon the ability of the liquid film comprising the wall of this hole to withstand tensile and compressive strains caused generally by external conditions. This desirable elastic property of the liquid film may be imparted to it if, and only when, the surface tension of the interface between the gas filling the bubble and the liquid forming its wall is capable of rapid change, even though small, but throughout a definitely measurable range.

Surface tension is the apparent contractile force existing at the boundary between two different phases or forms of matter, such as a liquid and its saturated vapor, two immiscible liquids, or a liquid and a solid. The source and nature of this force may be understood by a consideration of the following:

Matter is made up of minute particles called molecules. These molecules exert a force of attraction upon one another, and this force varies inversely as the distance between molecules. The force may therefore be considerable when the molecules are in close proximity, but diminishes rapidly as the distance increases, so that beyond a certain distance it may be considered negligible. If this certain distance is called d, then each molecule possesses a sphere of influence of radius d, and any molecule which comes within this sphere is attracted by the molecule at the center of the sphere, the latter molecule being in turn attracted by the molecule that has come within its sphere of influence.

That the vapor of a liquid is less dense than the liquid itself is common knowledge. This implies the fact that molecules in the vapor or above the surface of a liquid are, on the average, further apart than molecules below the surface of a liquid[1].

In Fig. 1 a molecule is represented by a dot and its sphere of influence is represented by a circle of radius d with the molecule under consideration as the centre. If the distribution of molecules per unit of volume be represented by the intensity of the shading caused by the number of dots per unit of area (no inference being intended as to the actual spacing, shape, and size of molecules in the liquid and in the vapor), it will be clear that molecule A is equally attracted in all directions, its sphere of influence being entirely within the liquid, and therefore the number and magnitude of pulls from a given element of the area (circle) are counterbalanced by an equal number of pulls from the corresponding, diametrically opposite element of the area. However, molecule B has one half of its sphere of influence in the liquid and the other half within the vapor. Therefore, in this case, the number and magnitude of the pulls from the area below the surface of the liquid are greater than the number of pulls from the area above the surface of the liquid, thereby giving a net downward resultant force. Molecule C will have no preferential attraction in any direction (disregarding a slight difference in vapor concentration with height above the liquid surface), inasmuch as its sphere of influence lies entirely within the vapor. This case is therefore parallel to that of molecule A, the only difference between the two being the number of molecules per unit area of circle.

Molecules at or near the surface of the liquid are apparently attracted towards the interior of the latter because of the difference in magnitude between the resultant upward and downward components of the intermolecular forces of attraction created by the greater spacing of similar molecules in the vapor of the liquid.

Surface tension, then, is a manifestation of the energy residing at a surface of a liquid—that is, it is the force component of the work (work being the product of force times distance) that is done in bringing molecules from the interior to the surface of the liquid.

Experience teaches that any system will spontaneously tend to reach a level at which the energy will be a minimum. Thus, water flows down over falls, a car will roll down a hill, and their capacity to do work after such a movement is less than it was before. Accordingly, for the reason that surface tension is a manifestation of surface energy, proportional in total to the total amount of surface, we find that

[1]The word surface is used here and will be used throughout for simplicity. As a matter of fact, it has been shown that there is a gradual transition from liquid to vapor in order to maintain equilibrium between the two phases, thereby giving a layer of variable density which has a finite thickness.

drops of liquids and bubbles tend to assume a spherical shape, since the sphere is the geometrical configuration which gives a minimum area for a given volume, and the total surface energy is thus reduced to a minimum. Further experiments have shown that substances which lower the surface tension of water tend to concentrate at

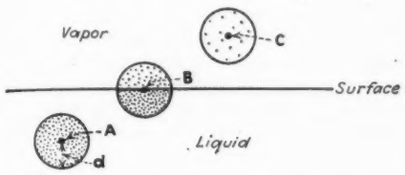


Fig. 1—Three molecules and their spheres of influence, of radius d. Molecule A is within the liquid, molecule B half within the liquid and half within the vapor, and molecule C is wholly within the vapor

the surface, whereas substances which increase the surface tension of water tend to concentrate away from the surface of the water. This, again, is clearly in complete accord with the principle of minimum energy, inasmuch as any other behavior of such substances would not produce a state of minimum surface energy.

A study of substances which lower the surface tension of water shows that they are, practically with no exception, organic compounds, whereas substances which raise the surface tension of water are inorganic compounds.

Fig. 2 shows a surface-tension curve obtained by adding a carefully prepared solution of oleic acid ($C_{17}H_{33}COOH$) in benzene drop by drop to a given, clean surface of water so that 30 drops of the solution gave a layer of oleic acid (the benzene evaporated) three molecules thick on the surface of the water. The curve shows the interesting fact that, although no substantial change occurs in the surface tension of water up to the addition of 10 drops, as soon as a complete monomolecular layer of oleic acid is obtained over the entire surface, the surface tension begins to fall rapidly with each additional drop, until a layer of oleic acid two molecules thick is reached. After that, further additions of drops give values for surface tension which approach asymptotically the value for the surface tension of oleic acid (oleic acid-air).

The conditions involved in frothing are best shown by an analysis of the following ideal experiment. Fig. 3 shows a U-shaped wire loop *ABGH*. *EI* is a wire slider which we may assume to move up or down on the loop without friction. The dotted area represents a film of pure liquid whose surface tension is equal to *T*.

At equilibrium $F = 2lT$, the 2 being introduced in the equation by the fact that the film, having thickness, will have two surfaces. If *F* is greater than $2lT$, then the slider *EI* will move down unimpeded until the film breaks, *l* and *T* remaining constant. If *F* is less than $2lT$, then the slider *EI* will move up until it coincides with *AB*. But, if we add an amount of oleic acid which will produce a surface layer between one and two molecules thick, and if we assume the dots in Fig. 3 to represent molecules of oleic acid, then when *F* is greater than $2lT$, the slider begins to move downward, but in so doing the liquid-air interfacial area will be increased, thereby lowering, at least momentarily, the concentration of oleic acid per unit area. Reference to Fig. 2 will show that this will cause an increase in surface tension which will then restore equilibrium. Similarly, if *F* is less than $2lT$, then as the slider begins to move upward, the liquid-air interfacial area will decrease, but in so doing the concentration of oleic acid per unit of area of interface will increase, at least momentarily, thereby lowering the surface tension, which will then restore equilibrium. Using parallel reasoning, it can be shown that a contaminant which raises the surface tension of water will also act as a film stabilizer.

Thus it is clear that a film contaminated within the range of rapid change in surface tension with small change in concentration has a capacity for automatic adjustment for external strains within its ultimate strength, and this implies a prolonged life of film.

Frothing experiments based on the determination of weight of froth overflow per unit volume of free air, per unit weight of frother, show that cresol is an excellent frother, and that methyl alcohol and sodium chloride are relatively poor. Fig. 4 gives surface tension curves for sodium chloride, methyl alcohol, and cresol. A study of these curves shows that cresol, for a relatively small change in concentration from *A* to *B*, gives a change in surface tension from *C* to *D*, whereas identical changes in concentration for methyl alcohol and for sodium chloride give relatively negligible changes in surface tension (*E* to *F* and *G* to *H*, respectively).

Sodium chloride is rather typical of inorganic substances with respect to their effect on the surface tension of water. This is one reason for the universal use of organic frothing agents. Further, even though at high concentrations some inorganic compounds (for example, sulphuric acid) cause rapid changes in the surface tension of water, the comparatively large amounts required, and the cost, make their use impracticable and uneconomical.

Apparently, therefore, it is a necessary characteristic of good frothers to produce marked and rapid changes in the surface tension of water for relatively small changes in concentration. This implies, in the case of good organic frothers, the fact that their molecules must concentrate readily at the interface between water and air.

A statistical analysis[2] of the structure of molecules of good organic frothing agents has shown that they are invariably made up of two distinct groups—namely, a hydrocarbon group (a group consisting of hydrogen and carbon

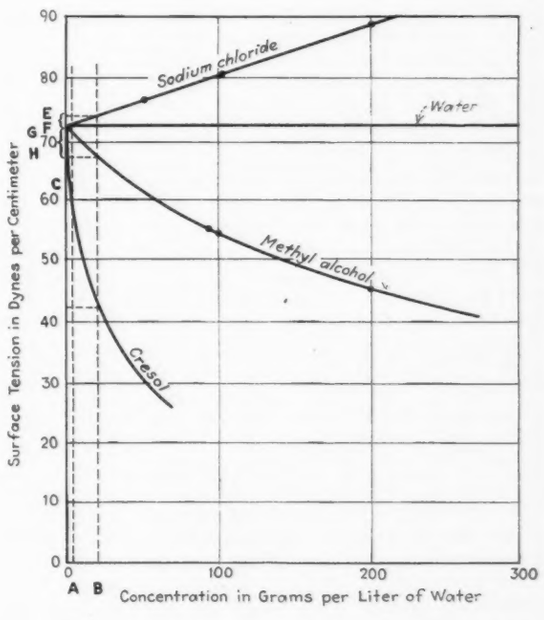


Fig. 2 — Surface tension curve obtained by adding prepared solution of oleic acid in benzene to a given clean surface of water

[2]A. F. Taggart, T. C. Taylor, and C. R. Ince: *Trans.* A.I.M.E. (1930) 87, "Milling Methods," 285.

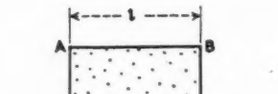


Fig. 3—A U-shaped wire loop ABGH, of width *l*, and a frictionless wire slider EI. The dotted area represents a film of pure liquid having a surface tension = T

molecules) and some one of the following groups: OH (hydroxyl), CO (carbonyl), COO (ester), COOH (carboxyl), CONH (amido), NH_2 (amino). Further, the analysis has shown that the solubility in water diminishes with increase in hydrocarbon loading. Clearly, then, in all these frothing agents the hydrocarbon group is the insoluble or water-repellent part of the molecule, and the hydroxyl, carboxyl and similar groups are the soluble or water-avid part of the molecule.

Generalizing, we may say, then, that the properties that a molecule must have in order to spread readily at an air-water interface are water-avidity and water-repellence. In other words, such a molecule must be attracted by the water and at the same time must be repelled by it. Without water-repellence, these molecules would be drawn into the interior of the water, and, on the other hand, without water-avidity the molecules would aggregate at the surface of the water and cause only a localized effect. If these opposite and antagonistic properties of the molecule are to have the desirable result, it is clear that they must not be properties of the molecule as a whole and must not merely neutralize each other, but must be properties of different parts of the molecule; that is, one part of the molecule must be water-avid and the other part must be water-repellent.

Now, if we combine water-avid groups with the hydrocarbon group we obtain the desired molecule. These molecules may be compared to matches, the head or business end of the match being the water-avid group and the rest of the match being the hydrocarbon or water-repellent group. When one of these molecules is added to water, the water-avid group (the head of the match) will be below the surface of the water, and the water-repellent part of the molecule (the stick of the match) will be sticking up above the surface of the water.

The frothing properties of these compounds depend also on their solubility in water, other things being equal. Thus, if to the phenyl group, C_6H_5, we add an hydroxyl group, OH, we get phenol with a solubility of about 60 grams per liter of water. This relatively high solubility connotes preference on the part of a phenol molecule for the body of the water rather than its surface. By replacing a hydrogen of the phenyl group of phenol, C_6H_5OH, with a methyl group, CH_3, we increase the size of the water-repellent group and thereby decrease the solubility. Cresol, $C_6H_4.CH_2OH$, with a solubility of about 30 grams per liter, is a better frother than phenol. If we replace still another hydrogen of the phenyl group of cresol with another methyl group, we get xylenol, $C_6H_3.CH_3.CH_3.OH$, which is even less soluble and a better frother than cresol. However, the hydrocarbon loading soon reaches a limit of beneficial effect. Thus, in another series, formic acid, HCOOH; acetic acid, CH_3COOH; propionic acid, $CH_3.CH_2.COOH$; and butyric acid, $CH_3.CH_2.CH_2.COOH$, are very miscible in water and are non-frothers; while with valeric acid, $CH_3.CH_2.CH_2.CH_2.COOH$; caproic acid, $CH_3.CH_2.CH_2.CH_2.CH_2.COOH$; heptoic acid, $CH_3.CH_2.CH_2.CH_2.CH_2.CH_2.COOH$; and so on to capric acid, $CH_3.(CH_2)_8.COOH$, the frothing effect increases with hydrocarbon loading and the solubility decreases accordingly. However, further addition to the hydrocarbon loading makes the higher members of this series rate as insoluble, and then no frothing properties may be expected.

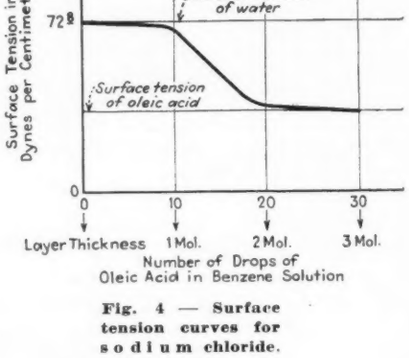


Fig. 4 — Surface tension curves for sodium chloride. methyl alcohol, and cresol

Frothing tests with members of any similar series have shown that, in all series, frothing properties are practically zero for members completely miscible in water and also for members which are substantially insoluble.

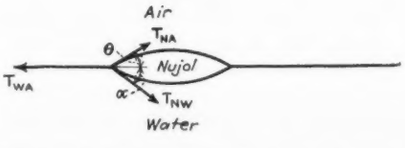
Other frothing experiments show that some water-avid groups may be more effective than others. Thus, if we replace the OH group in phenol, $C_6H_5.OH$, with NH_2 we get aniline, $C_6H_5.NH_2$. Aniline is considerably less vigorous as a frother than phenol, and its solubility is about half that of phenol. Inasmuch as the only difference between the two lies in the water-avid group, it follows that the NH_2 group is not as water-avid as the OH group and therefore is less capable of imparting to the molecule the desirable property of rapid orientation at a water-avid interface. Toluidine, $C_6H_4.CH_3.NH_2$ (aniline with an H replaced by CH_3) is also less vigorous as a frother than its corresponding analog, cresol, $C_6H_4.CH_3.OH$, although superior to aniline. The same is true of xylidine, $C_6H_3.CH_3.CH_3.NH_2$ (toluidine with an hydrogen replaced by a CH_3 group), which we find inferior as a frother to its analog, xylenol, and even to cresol; although xylidine is a better frother than toluidine. The other water-avid group containing nitrogen—namely, the amido group—has, in many instances, a harmful effect on collection.

In commercial practice, the best frothers are not pure frothing compounds, but mixtures of frothing agents and inert hydrocarbons. Thus, steam-distilled pine oil, an essential oil, is a mixture of hydro-aromatic alcohols (the active frothers) and hydro-aromatic hydrocarbons. Crude cresylic acid is chiefly a mixture of cresol and xylenols, the active frothers, in an inert oil.

Although no visual difference in frothing effect is apparent between terpineol and steam-distilled pine oil when added to water alone, it is common experience that when solids are present in the water steam-distilled pine oil gives better results than terpineol. The reason for this is probably due to a spreading of the inert oil at the air-water interface of the bubble, this film apparently furnishing a better collecting surface for solid particles which upon attachment to the bubble key one another in place, giving a so-called armored bubble. The closely crowded particle coating adds considerable strength to the bubble wall, thereby making it more persistent. The halftone cut on page 152 shows a photomicrograph of an armored bubble.

The spreading of the inert oil at the air-water interface is caused by the active frothing agent present, as may be demonstrtaed by the following experiment: If a large drop of nujol (a mixture of highly refined hydrocarbons, insoluble in water) is added to a clean surface of water, the nujol, being water-

Fig. 5—Diagram demonstrating equilibrium relaNonships for the surface tensions, water - air, nujol-air, and nujol-water



repellent and having a specific gravity less than that of water, will assume a lens shape and float on the surface of the water, as shown in Fig. 5. If a fine drop of steam-distilled pine oil is injected into the nujol-air interface, nothing happens for a while (this time depends on the size of the nujol drop), but suddenly the nujol spreads over the entire surface of the water. An analysis of the surface tensions at the interfaces involved indicates the mechanism of this spreading. In Fig. 5, if we indicate the surface tensions of water-air, nujol-air, and nujol-water by T_{wa}, T_{na}, and T_{nw}, respectively, then at equilibrium we have:

$$T_{wa} = T_{an} \cos\theta + T_{wn} \cos\alpha$$

The fact that the nujol spreads over the surface indicates that equilibrium is destroyed. This means that either T_{wa} is increased or that either one of the quantities $T_{wa} \cos\theta$ or $T_{wn} \cos\alpha$ is diminished. We know from other experiments that steam-distilled pine oil lowers T_{wa}. If steam-distilled pine oil had lowered T_{na}, then a change should have occurred as soon as the nujol lens had been contaminated with pine oil. The fact that there is time lag indicates that the steam-distilled pine oil lowers the nujol-water interfacial tension, and the time factor is dependent on the diffusion rate of pine oil in nujol in order for it to reach the nujol-water interface.

In practice, it is important to add the correct amount of frothing agent in order to obtain the desired results. Over-oiling has the effect of causing numerous relatively small bubbles, which are very persistent. This makes it difficult for solid particles to settle out, and therefore a large amount of solids, no matter how undesirable, are carried over with the concentrate, mechanically entrained. Over-oiling has also the effect of lowering recovery. The reason is entirely obscure.

Under-oiling causes a watery, nonpersistent froth, and to obtain a given overflow the cell is "forced" by using more air. This causes a more powerful upward current in the flotation cell, which then carries more solids with the overflowing water. Under-oiling also causes a lowering in recovery.

Frothing tests have also shown that if a large amount of frothing agent is already in use, little increase in frothing effect may be expected by further additions of reagent.

Recapitulating, good frothers are organic compounds with a solubility of around 1 gram per liter of water, of the general form R $\left\{\begin{matrix}\text{OH}\\\text{COOH}\\\text{CO}\\\text{COO}\end{matrix}\right.$, where R is a hydrocarbon with a carbon content equal to about six. These compounds concentrate at the air-water interface and function by causing rapid changes in surface tension for relatively small changes in concentration.

Gas-Engine Repair

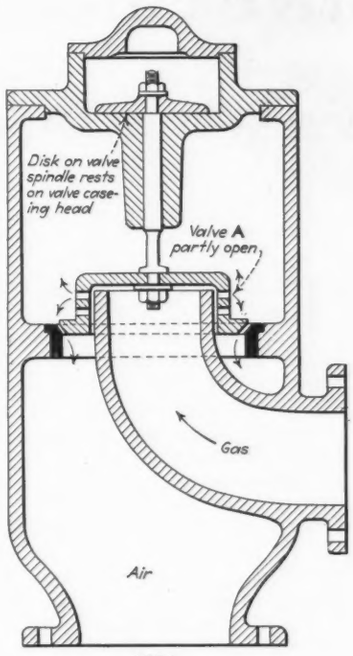


FIG. 1

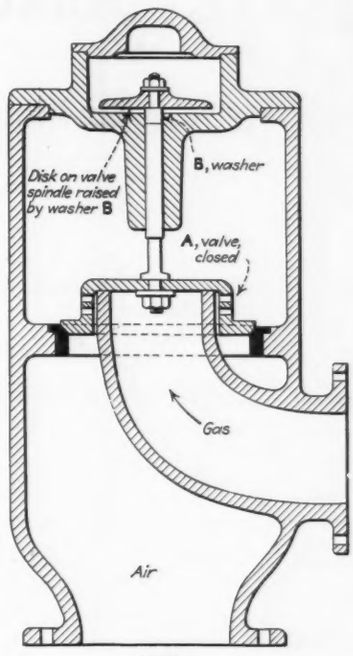


FIG. 2

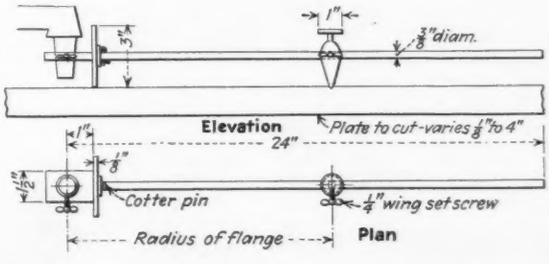
MUCH TROUBLE was experienced recently with one of our 75-hp. gas engines, writes T. W. Allmand, master mechanic of a mining company operating in northern Mexico. During a periodic shutdown the engine was thoroughly overhauled and cleaned.

After several vain attempts to start the engine, one of the attendants noticed gas escaping from the air intake line. No one could explain this phenomenon until the mixing valve was removed. An inspection of the valve revealed that repeated regrinding of valve *A* (see accompanying illustration) had gradually reduced the prescribed play between the disk attached to the end of the valve spindle and the floor of the valve casing head, until the disk finally came to rest upon the casing-head floor, thus keeping valve *A* partly open and permitting gas to enter the mixing chamber proper (Fig. 1) and the air-intake line. The piston thus sucked almost pure gas into the combustion chamber of the engine, which would not ignite during compression.

With no spare valve at hand, the difficulty was overcome by placing the machined washer *B* between the recess at the end of the valve spindle and the disk proper, as shown in Fig. 2.

Cutting True Circles

A SIMPLE DEVICE made and used in one mine shop for cutting true circles with the oxy-acetylence torch is shown in an accompanying sketch. Circles of steel from 5 to 48 in. diameter can be easily cut, and almost any thickness of plate up to 4 in. can be used. This device does such smooth work that machining is not needed to make a good-looking job. By setting the wing screw against the cutting head, the latter is clamped at the proper height, thus leaving the operator free to guide the head around the circle. Much faster work with less gas results with the tool.



REAGENT CONSUMPTION

In Flotation Plants of the United States

Table I—Ores Treated and Concentration Ratios Obtained

Class of Ore Treated	Ore Treated, in 1,000 Tons—Straight Gravity	Ore Treated, in 1,000 Tons—Combined Gravity and Flotation	Ore Treated, in 1,000 Tons—Straight Flotation
Copper	..	2,022	8,956
Copper-lead	..	.....	165
Lead	3	4,316	36
Lead-zinc	24	1,909	1,142
Zinc	12	1,106	194
Gold-silver	12	203	98
Totals	51	9,556	10,591
Copper	.....	21.3 :1	8.154:1
Native copper	35.81:1	.....	193.30: 1
Lead	.....	15.96:1	15.78 :1
Lead-zinc	.....	14.0 :1	3.17 :1
Zinc	.....	25.47:1	11.84 :1

Table II—Reagent Consumption in Treatment of All Ores

	Reagent Consumption Total in 1,000 Lb.	Reagent Consumption Lb. per Ton Ore
I. Frothers:		
Pine oils	1,189	0.105
Cresylic acid	1,188	0.165
Total frothers	2,377	0.147
II. Collectors:		
1. Distillation products:		
Coal-tar creosotes	422	0.190
Wood-tar creosotes	1	0.036
Petroleum products	1	0.001
Blast-furnace oils	75	0.122
Total	499	0.117
2. Synthetic products:		
Ethyl xanthates	717	0.085
Butyl xanthates	172	0.086
Amyl xanthates	120	0.035
Xanthate derivatives	36	0.011
Dicresol-dithiophosphoric acid	164	0.043
Sodium dicresol-dithiophosphate	91	0.044
Sodium diethyl-dithiophosphate	40	0.013
Thiocarbanilide	14	0.091
Total	1,354	0.085
Total collectors	1,853	0.115
III. Acids and alkalies:		
1. Acids:		
Sulphuric	1,202	0.072
2. Alkalies:		
Sodium carbonate	666	0.559
Sodium hydroxide	56	0.391
Lime	44,547	3.512
Total alkalies	45,269	3.435
IV. Other inorganic reagents:		
1. Sulphidizing:		
Sodium sulphide	444	0.187
2. Activating:		
Copper sulphate	2,067	0.674
3. Depressing:		
Cyanides	208	0.033
Sodium sulphite	341	1.092
Sodium silicate	99	0.310
Zinc sulphate	815	0.374
Sodium bichromate	9	0.206
Total depressing	1,472	0.217
4. Miscellaneous:		
Sodium chloride	36	1.070
Starch	49	0.848
Chlorine	28	0.825
Total reagents	54,798	3.399

Abstracted from Statistical Appendix to Minerals Yearbook 1932-33.

THE total production of nonferrous ore in the United States in 1932 was 26,321,679 tons, compared with 54,764,842 tons in 1931, about 76,725,000 tons in 1930, and about 106,179,000 tons in 1929. Of this decrease the larger part is accounted for by the curtailment in the output of copper ore, although this ore still amounts to nearly half of the total. Of the total tonnage of ore produced, 76.74 per cent (20,198,804 tons) was treated by concentration, 4.11 per cent was shipped directly to smelters, 13.75 per cent was treated at gold and silver mills, and the remaining 5.40 per cent was treated at miscellaneous plants, including copper-leaching plants, magnetic-separation plants, and slag-fuming plants. Practically all the ore concentrated was treated at plants having flotation equipment.

Table I gives the tons of ore treated and the concentration ratio obtained by flotation, gravity concentration, and combination of the two methods during 1932. Consumption of flotation reagents for all classes of ores in 141 plants, treating 16,124,007 tons of ore, is presented in Table II. The trend in the reagent consumption is shown in Table III, where the figures for the years 1928-32 are compiled. A summary of the reagents used in the treatment of the different metals is presented in Table IV.

Table III—Comparison of Reagent Consumption, 1928-32

	1928	1929	1930	1931	1932
Ore treated, thousand tons	59,064	65,405	47,259	35,956	16,124
Reagent consumption, thousand pounds:					
Frothers	9,052	9,283	7,106	5,508	2,377
Collectors:					
Distillation	3,021	2,345	1,107	753	499
Synthetic	4,863	5,925	5,018	3,543	1,355
Acids	12,442	12,099	12,060	11,143	1,202
Alkalies	215,858	234,598	154,424	115,744	45,269
Sulphidizing	2,399	2,589	1,226	643	444
Activating	6,898	6,723	5,390	3,325	2,067
Depressing	9,500	6,050	4,393	2,409	1,585
Total reagents	264,033	279,612	190,724	143,068	54,798
Reagent consumption, pounds per ton of ore treated:					
Frothers	0.155	0.144	0.152	0.153	0.147
Collectors:					
Distillation	0.128	0.124	0.106	0.126	0.117
Synthetic	0.082	0.091	0.107	0.100	0.085
Acids	27.716	22.030	24.933	21.342	0.072
Alkalies	3.873	3.735	3.560	3.852	3.435
Sulphidizing	0.329	0.713	0.154	0.723	0.187
Activating	0.721	0.627	0.697	0.593	0.674
Depressing	0.287	0.213	0.239	0.174	0.230
Total reagents	4.470	4.275	4.036	3.979	3.399

Table IV—Summary of Reagent Consumption for the Individual Metals

	Copper	Copper (Native)	Lead	Lead-Zinc	Zinc	Gold and Silver
Ore treated, thousand tons	9,726	623	2,921	1,389	664	801
Number of plants	15	5	25	36	14	46
Reagents (pound per ton of ore):						
I. Frothers	0.142	0.096	0.186	0.160	0.113	0.116
II. Collectors:						
1. Distillation	0.038	.....	0.015	0.675	0.192	0.147
2. Synthetic	0.060	0.132	0.095	0.243	0.084	0.072
III. Acids and alkalies:						
1. Acids	0.839	.....	.....	0.039	0.002	0.139
2. Alkalies	4.368	0.357	0.206	1.341	2.848	0.764
IV. Other inorganic reagents:						
1. Sulphidizing	0.005	.....	0.395	0.608	.....	0.304
2. Activating	.....	.....	0.092	1.052	0.674	0.322
3. Depressing	0.020	.....	0.142	0.953	0.073	0.053
4. Miscellaneous	.....	.....	.....	1.070	.....	0.839
Total reagents	4.708	0.308	0.577	3.745	1.992	0.756

A Cyanide Plant in Japan

Gold-Silver Ore Treated in 350-Ton Mill

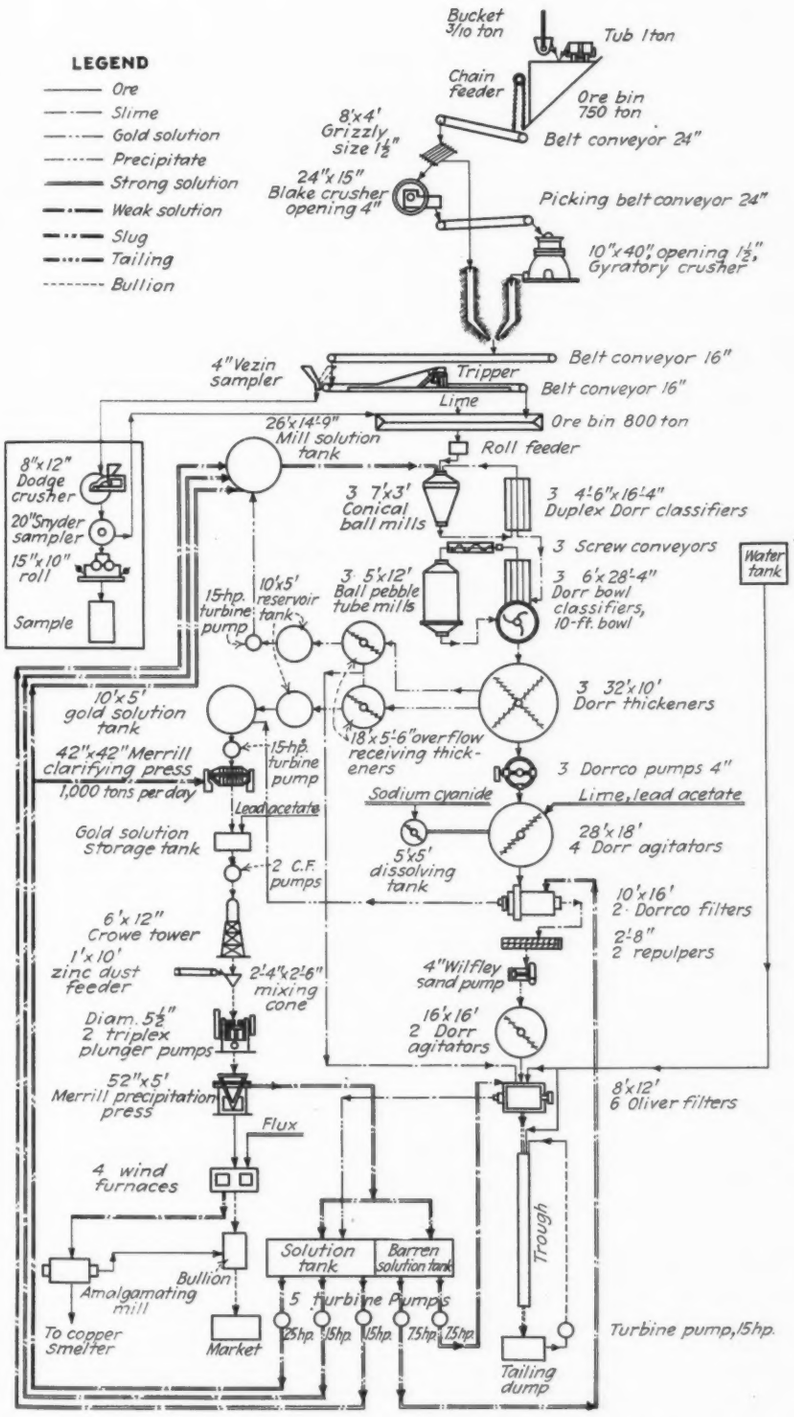


Fig. 1—Flowsheet of 350-ton cyanide plant, Sumitomo Konomai Gold Mines

THE MILL of the Sumitomo Konomai Gold Mines Company, at Monbetsu-Machi, Monbetsu-Gun, Hokkaido, Japan, has a capacity of 350 tons per day. About 1 per cent of the ore is iron pyrite. A flowsheet is presented herewith. The ore is delivered from underground into a 750-ton crude-ore bin, from which it is drawn, by chain feeder, onto a 24-in. belt conveyor, thence onto a 8x4-ft. grizzly with 1½-in. openings. Oversize passes to a 24x15-in. Blake crusher, with a 4-in. opening, the product passing to a 24-in. belt conveyor. Waste is picked by hand from the conveyor, and the remainder of the ore discharged to a 10x40-in. gyratory crusher, set at 1½-in. opening.

Undersize from the gyratory, with the undersize from the grizzly, passes to a 16-in. belt conveyor. At the point where this conveyor discharges onto another 16-in. conveyor, a sample is taken by a 4-in. Vezin machine. From the second conveyor the ore falls into an 800-ton ore bin.

Equipment in the sampling department includes an 8x12-in. Dodge crusher, a 20-in. Snyder sampler, and a pair of 15x10-in. rolls.

A roll feeder delivers the ore from the aforesaid ore bin to three 7x3-in. Hardinge ball mills (5-in. steel balls; consumption 2.33 kg. per ton). These operate in closed circuit with three duplex Dorr classifiers, 4 ft. 6 in. wide and 16 ft. 4 in. long. Undersize from the classifiers passes to three ball-pebble mills (2-in. steel balls; consumption 1.86 kg. per ton), each 5x12 ft., which are in closed circuit with three Dorr bowl classifiers, each 6x28 ft. 4 in. long and with a bowl diameter of 10 ft.

Lime is added to the ore in the 800-ton bin, and weak cyanide solution enters the circuit with the feed to the Hardinge mills. Extraction in the Hardinge grinding circuit amounts to 30 per cent of the gold and 20 per cent of the silver in the ore. Each classifier in circuit with the Hardinge mills requires 3 hp. The rakes of these classifiers operate at a speed of 25 strokes per minute, over a slope of 3-in. to the foot. Classifiers in circuit with the pebble mills require 5 hp., and the extraction effected after the ore has

passed this circuit totals 45 per cent of the gold and 30 per cent of the silver. Rake speed is eighteen strokes per minute, over a slope of 2 in. to the foot.

Overflow from the Dorr bowl classifiers, the screen analysis of which is shown in Table I, passes to three 32x10-ft. Dorr thickeners. Overflow from the thickeners is delivered by three Dorrco pumps to four 28x18-ft. Dorr agitators, where a strong solution of sodium cyanide from a dissolving tank is added, as well as lime and lead acetate. Ratio of solution to solids in these units is 1:1. Cyanide strength, in terms of potassium cyanide, amounts to 0.2 per cent; protective alkalinity, in terms of CaO, is maintained at 0.07 per cent. The time of agitation averages 60 hours, involving a power requirement for each agitator of about 10 hp., in addition to an air consumption of 60 cu.ft. per minute, delivered at a pressure of 20 lb. These agitators are operated in series, and therefore always remain full of pulp. Cumulative extraction in each unit is as follows: No. 1 agitator, 72 per cent gold, 42 per cent silver; No. 2 agitator, 87 per cent gold; 69.5 per cent silver; No. 3 agitator, 88 per cent gold, 73 per cent silver; No. 4 agitator, 89 per cent gold, 80 per cent silver.

Pulp from the final Dorr agitator passes to a 10x16-ft. Dorrco filter, the cake from which is re-pulped and delivered by a 4-in. Wilfley sand pump to two 16x16-ft. Dorr agitators, operating at 3 r.p.m. In these units the ratio of solution to solids is also 1:1. A cyanide strength, in terms of potassium cyanide, of 0.15 per cent is maintained. Protective alkalinity amounts to 0.05 per cent in terms of CaO. Agitation is continued for ten hours, involving a power requirement for each agitator of 8 hp., in addition to a consumption of 50 cu.ft. per minute of air at a pressure of 20 lb. Cumulative extraction at this point is as follows: No. 1 agitator, 91.5 per cent gold, 82 per cent silver; No. 2 agitator, 92 per cent gold, 83 per cent silver.

From the final agitator, the pulp passes to six 8x12-ft. Oliver filters, equipped with 12-oz. twill-weave cotton duck, which lasts about six months after having been washed once a week with a 5 per cent solution of hydrochloric acid. A 25-in. vacuum is maintained, and each unit has a capacity of about 60 tons per day, with a drum speed of 6-8 r.p.m. Discharge air is delivered at a pressure of 15 lb. Cloth on the Dorrco filters, which are also given an acid treatment, is similar to that used on the Oliver filters. Tailing from the Oliver filters is delivered by flume to a tailing pond, transport being aided by the addition of decanted water from the pond. This water is returned by means of a turbine pump driven by 15-hp. motor.

Overflow from the Dorr thickeners is divided between two thickeners, 18 ft. in diameter and 5 ft. 6 in. deep. Overflow from one of these passes to a 10x5-ft. reservoir tank, from which it is pumped to a mill solution tank, 26 ft. x 14 ft. 9 in., delivering by gravity to the Hardinge mills. Overflow from the second receiving thickener passes to a second 10x5-ft. reservoir tank, and thence to a 10x5-ft. gold-solution tank, from which it is delivered to a Merrill clarifying press, with 42x40-in. plates, capable of treating 1,000 tons per day. The clear solution passes to a gold-solution storage tank, where lead acetate is added, and thence to a 6x12-ft. Crowe process tower. From the tower the solution passes to a mixing cone, 2 ft. 4 in. x 2 ft. 6 in., for precipitation with zinc dust, in the usual manner. Two 5½-in. triplex plunger pumps deliver the underflow of the cone to a Merrill precipitation press, 52 in. x 5 ft., the cakes from which are fluxed and smelted in the usual type of natural draft furnace.

The fuel used is coke and charcoal. The flux consists of the following: For 100 parts of precipitate, 12 parts soda, 5 silica, 15 borax, 10 slag, and also iron scrap.

Analysis of precipitate from the Merrill press is as follows: Gold, 3 to 4 per cent; silver, 55 to 60 per cent; impurity unknown.

The resultant bullion has the following composition: silver, 93.69 per cent; gold, 5.05 per cent. Slag from the smelting operations is amalgamated in a barrel mill, the resulting amalgam retorted in the usual manner, and the sponge added to the bullion from the smelting furnaces. The slag is sent to the smelter.

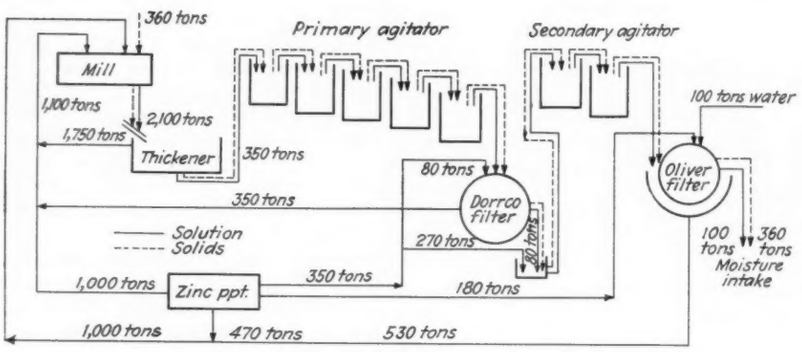


Fig. 2—Flow of solution and solids, Sumitomo Konomai cyanide plant

Table I—Screen Analyses of Mill Products

Minus	Plus	Feed to Ball Mills, per Cent	Feed to Ball Pebble Mills, per Cent	Final Ground Product to Thickeners, per Cent
.....	1.050 in.	9.40	....	....
1.050 in.	0.742 in.	20.60	....	....
0.742 in.	0.525 in.	24.50	....	....
0.525 in.	0.371 in.	10.25	....	....
0.371 in.	3 mesh	15.35	....	....
3 mesh	4 mesh	3.82	....	....
4 mesh	6 mesh	2.45	....	....
6 mesh	8 mesh	2.51	....	....
8 mesh	10 mesh	1.50	....	....
10 mesh	14 mesh	1.48	....	....
14 mesh	20 mesh	1.30	1.76	....
20 mesh	28 mesh	1.02	2.73	....
28 mesh	35 mesh	0.85	7.25	....
35 mesh	48 mesh	0.56	10.93	....
48 mesh	65 mesh	0.52	10.55	....
65 mesh	100 mesh	0.44	10.93	....
100 mesh	150 mesh	0.52	8.21	3.85
150 mesh	200 mesh	0.31	7.83	11.51
200 mesh	.....	2.76	39.06	84.64

Table II—Power Consumption Data

	Kw. per Ton
Coarse Crushing	0.6
Conveying and Sampling of Dry Ore	0.5
Ball Milling	17.0
Pebble Milling	16.0
Classification	0.4
Thickening	0.2
Agitation	2.5
Filtration	8.5
Precipitation	0.5
Pumping	5.4

Table III—Metallurgical Results, April, 1933

Tons (metric) ore treated	10,000
Gold recovered, kg.	100.49503
Silver recovered, kg.	1,725.25823

Ore to mill
Assay: silver, 193.3 grams per ton; gold, 11.1 grams per ton.
Total content: silver, 1,932.55823 kg.; gold, 111.39503 kg.
Tailing
Assay: silver, 20.73 grams per ton; gold, 1.09 grams per ton.
Total content: silver, 207,300 kg., gold, 10.9 kg.
Assay extraction, per cent: gold, 90.22; silver, 89.27.
Actual recovery, per cent: gold, 90.22; silver, 89.27.

Precipitate Treatment

At Jackson, California . . . Amador Metals Develops Economical Procedure for Making 990 Fine Bullion

S. E. Woodworth

Hamilton, Beauchamp & Woodworth, San Francisco

THE METHOD of treating cyanide precipitates at the plant of the Amador Metals Reduction Company, as in so many plants, is the result of intensive study to develop a standard procedure that would produce a marketable bullion at least expense and difficulty, and at the same time reduce slag losses to a minimum. A brief description of the process, therefore, should be of interest to the gold metallurgist and mill operator at large.

The Amador plant at present is treating about 8,000 tons a month of carbonaceous or graphitic tailing from the mill of the Argonaut Mining Company at Jackson, averaging $0.93 per ton. Precipitation is accomplished by zinc dust, fed to the Crowe solution circuit through a Merrill cone by a screw feeder. The de-aërated solution then passes to the suction of a centrifugal pump which discharges into a set of precipitation filter bags immersed in barren solution. This pump has a hydrostatic head of about 4 ft. upon its suction, because the Crowe tower is so placed that its discharge acts through a vacuum leg to give this effective head. No difficulty is experienced with oxidation of the de-aërated solution due to leaking of the solution-lubricated pump stuffing gland. Double precipitation bags are used. The outside bag is made of No. 12 duck and is 5¼ in. in diameter and 36 ft. long, with a sewed-in flat bottom. Effective filtering area is 4 sq.ft. The inside bag is slightly larger, so as to avoid all strain, and is made of the finest woven sheeting. With this arrangement 3.2 tons of solution per square foot of effective filtering surface can be precipitated a day at a maximum pressure of 4 lb. per square inch. The values of the solutions handled and consumption of major chemicals used are given in the accompanying table.

Cyanide consumption is chiefly accounted for by the fact that milling and collecting are done in water, which necessitates the elimination of a large quantity of barren solution. About 2.1 tons of solution are precipitated per ton of ore. Nearly 1 ton of barren solution is wasted for every ton of ore treated. Most of the lime is used for settlement purposes, although some small amount of 20-mesh granulated lime is charged with the sands as the tanks fill.

Clean-up Procedure

When cleaning up, each bag assembly is transferred to a lead-lined acid tank equipped with a mechanical agitator and there opened. Because the bags are lashed to cast-iron heads by twine, the contents are easily removed and the bags turned inside out and washed. The precipitate is treated with sulphuric acid. When no further action takes place, a filter aid known as "Hyflo" (a special brand of diatomaceous earth) is added in quantity equal to about 8 per cent of the weight of the precipitate under treatment, and the solids are allowed to settle. Clear liquor is decanted to a vacuum filter and the acid tank filled with boiling water. These contents are again agitated, then allowed to settle, and the clear liquor is decanted. After this solution has passed through the filter, the sludge is transferred to the same filter. The filter cover, composed of very fine sheeting which is placed over the filter paper laid on the permanent filter cloth calked into the periphery of the tub, is also given a light coating of "Hyflo" as soon as it is placed in position. This makes the sheeting impervious to precipitate. Prior to the use of this material it was difficult at times either to settle the precipitate or to filter the liquor. No attempt is made to remove all the soluble sulphates by washing with water before or during filtration, as the time cannot be spared.

No difficulty is encountered with the sulphates in melting, for this is done in a refractory-lined crucible which yields a bullion averaging 990 fine. As a result of experimentation by the staff with oxidizing slags in pots lined with various refractory materials, the Joseph Dixon Crucible Company, of Jersey City, N. J., became interested in the problem and developed, and is now manufacturing, pots lined with a material designated as J-50 refractory lining for use with a niter-manganese-lead-silicate flux. The slag loss with a high oxidizing flux, when used in these crucibles, should not exceed $0.10 per pound. Fusion is made in No. 125 pots, which are lifted from the furnace by tongs and block and tackle. To facilitate pouring the contents of the crucible, the tongs have a lug welded to the back of each clasping member, which lugs act as trunnions the moment they rest in the notched ends of the two uprights of the stand into which the crucible has been lowered. The mold rests on a carriage that can be moved forward for convenience of the melter.

Precipitate, after drying, is moistened with a water spray, mixed with flux, and finally forced through a screen so that all lumps are broken and a uniform mixture is assured. The moisture content of the mixture is just sufficient to avoid dusting. The pot is filled from a scoop, and as the charge melts and settles, more fluxed precipitate is added until the pot is well filled with a molten mass. Then the liquid sulphates float-

Value of Solutions—Consumption of Chemicals

		Dollars per Ton Solution
Average pregnant solution		$0.32
Average barren solution		0.0053
Precipitation efficiency	98.36 per cent	
Ratio gold to silver	3.34 to 1	

	Per Ton Ore	Per Ton Solution	Per Oz., Fine Bullion	Strength of Solution, per Cent
Zinc dust, lb.	0.0835	0.04559	2.260	
Lead acetate, lb.	0.00805	0.00415	0.161	
Sodium cyanide, lb.	0.233			0.025 — 0.02KCN
Lime, lb.	2.54			0.025 — 0.02CaO
Coal tar, gal.	0.244			
Water, tons	2.89			
Electric power, kw.-hr.	6.08			

ing on top of the slag are ladled into a conical mold and allowed to cool. They contain no gold or silver. Should any slag be ladled into these molds through carelessness, it sinks to the bottom of the cone and is saved when the solidified sulphate is rejected. If any fluxed precipitate remains, it is charged on top of the slag, and when melted the molten sulphates are removed before pouring.

Sampling

After thoroughly stirring the slag above the molten metal with an iron rod, a sample is taken and chilled in water and then bucked and panned. The quantity of prills observed indicates whether the charge is ready to be poured. When ready, the pot is removed and the slag and metal are poured into a bar mold, the overflowing slag being caught in a pan placed under it. As soon as the bar has cooled sufficiently, it is taken from the mold, then placed in water, where the slag is removed, and cleaned in the conventional manner. This is the finished bar and is not remelted prior to shipping. General practice at many plants is to pour the bullion into a conical mold, and then remelt or refine the bar if necessary. As no matte is made at the Amador plant, because of the high niter flux used, a remelting of the bars is unnecessary.

The economy of making and shipping high-grade bullion has often been questioned. Experience at the Amador plant has shown the practice to be both efficient and economical. Whether the precipitate be acid-treated or melted without previous treatment, the fineness of the bullion, if the charge be melted in a suitable refractory-lined pot or furnace with a highly oxidizing flux, does not change materially. However, the cost of melting untreated precipitate is greatly increased, owing to its larger bulk, which necessitates more fuel, labor, and flux. The quantity of flux used is based upon a percentage of the weight of the dried acid-treated precipitate as follows: Silica, including the filter aid, 12½ per cent; borax, powdered, 25 per cent; manganese dioxide, 2 per cent; fluorspar, 5 per cent; and crude niter, 40 per cent.

A Profit on Slag

Usually, the quantity of slag and fused sulphates formed is about half the weight of precipitate and has a value varying from $0.08 to $0.15 per pound. The assay of the slag may seem to be somewhat high, but over a year's run, producing bullion averaging slightly less than 990 fine in gold and silver, only 0.004 per cent of the value is retained in the slag and a large part of this is recovered at the smelter to which a yearly shipment is made. Incidentally, the yearly accumulation of assay slag and cupels is shipped profitably at the same time, chiefly for its lead content, although payment is obtained for the small amount of contained gold and silver.

The saving that can be effected by shipping very fine bullion can best be illustrated by a concrete example. For instance, take a 1,000-oz. bar of 700 fineness in gold and silver. The smelter "bar charge" will be $0.04 per ounce. In addition to this there is an alloy charge, and a charge based upon the number of fine ounces. For this comparison, these last two charges need not enter into the calculation. In the case of the 1,000-oz. bar, the "bar charge" would be $40, or $0.0571 per fine ounce of bullion. If this same quantity of fine bullion had been contained in a bar of 985 fineness, the bar would have weighed 710.6 oz. In this case the "bar charge" would have totaled $28.42, or $0.0406 per ounce of fine bullion. This shows a saving of $11.58 per bar, or $0.0165 per fine ounce of bullion. Another saving that would accrue to the shipper is the difference in shipping charges, which are based not upon value only but on weight as well.

If low-grade bullion is shipped, the smelter often penalizes the shipper when in its opinion the bar does not look uniform in composition or matte is attached to it. In such cases, lead is added to the bar and it is remelted to obtain a homogeneous sample. When this is done the regular "bar charge" is applied to the resultant weight of the remelted bar. Obviously, the increase in cost in shipping such bullion depends on the quantity of lead added.

Cost of Flux

As to cost of flux, there is no great difference between that of the high-niter mixture and that of the conventional sodium carbonate flux. An increased cost, however, is incurred for the refractory-lined J-50 crucibles. Using No. 125 pots, the additional charge over the plumbago crucible would be $6.25 per pot. As each pot withstands six to ten clean-ups, this additional cost per ounce of fine bullion is only a small item. Fuel consumption and melting time are about the same using either flux. Theoretically, the refractory-lined pot should require more time and fuel, as the walls are somewhat thicker and the heat transfer is slower. The difference, however, is so slight that it has not been noticed. Practically no liner corrosion takes place when using the flux described. The life of the pot depends on the degree of cracking, which can largely be controlled by slow, careful heating and cooling.

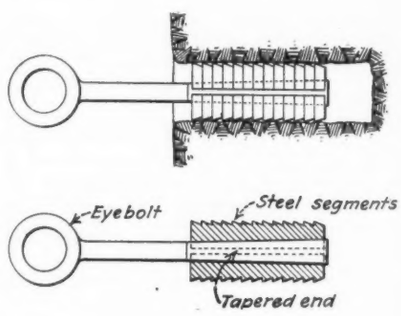
As soon as the last bar has been poured, the pot is returned to the furnace and allowed to cool with it. Failure of a pot liner while melting, which happens only when the pot has been used for too many heats, is apparent by the dense, white sulphur fumes driven off during violent boiling of the charge. This is caused by the interaction of the molten mass and the plumbago crucible. Under such conditions the charge should be transferred to another pot immediately.

Insurance is carried under a marine policy covering the value of the precipitate for all risks, from the time it is formed in the pipes leading to the bags until it is delivered to the smelter or mint. The cost of this policy is about 10c. per $100 value, the rate depending on the risk.

Self-adjusting Scraper-Block Eyebolt

AN IMPORTANT CONSIDERATION in underground scraping, to insure continuous operation at minimum cost, is to provide a practicable and simple tailblock eyebolt. Depending on the nature of the ground, two methods are employed. In soft ground the bolt is either cemented in, or suspended from, a boom or sprag-braced between the last cap and the breast, whereas in normal ground Lewis wedges are used to hold the eyebolt in place in the rock at the face.

Obviously, much time is consumed when a change of location is made, and often the bolt cannot be recovered, causing extra expense. This can be successfully overcome, in normal or hard ground, by using the simple eyebolt shown in the accompanying sketch. It consists, essentially, of the bolt proper,



containing a tapered tail, and two tempered steel segments. Pressure exerted at the eye of the bolt forces the segments against the wall of the opening, thus anchoring the bolt securely to the breast. A few blows of the hammer suffice to retire the taper to loosen the segments, after which the device can be extracted from the hole without difficulty.

Sink-and-Float Testing

Method and Apparatus for Larger Samples

F. J. Tolonen

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and Technology,
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NEED exists in ore testing for determining accurately the possibilities of concentrating ores and other mineral products. Washability tests and the curves derived from them have been used in coal preparation for three decades. Their application to the study of other minerals is being extended as their value becomes more generally known. From these curves and others that can be easily derived from them, one can determine the degree of grinding necessary, the grade of concentrate, the metal recovery, and the losses, and can also study ways of effecting the best possible separation and the economic possibilities. A comparison of results obtained in actual practice with those shown by the curves makes possible the determination of efficiencies.

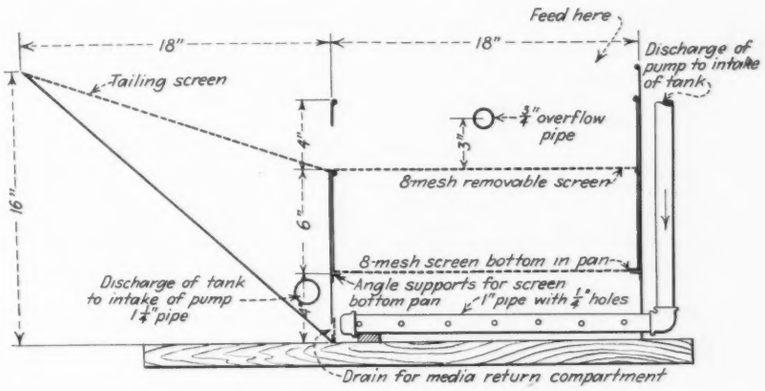
Several methods can be used for obtaining the necessary data for these curves. Hydraulic classifiers can be employed on closely sized feed with fairly good results. Laboratory and mill ore-dressing machines carefully operated with special sampling devices can also be used. The accuracy of the results obtained depends upon too many factors other than specific gravity to be entirely satisfactory as standards of comparison for gravity separations in ore dressing.

The ideal method of obtaining these data is by fractionating the samples by means of heavy solutions. Screen sizing is not necessary beyond the removal of sizes that will not settle in a reasonable time in the fluid used. The chief obstacle to the general use of heavy solutions has been their high cost. In coal testing, where the necessary specific gravity is below 1.8, extensive use has been made of calcium and zinc chlorides, as these are relatively cheap. Where higher specific gravities are necessary, only small samples can be tested with the more expensive solutions.

To extend this method of testing to larger samples and sizes, the apparatus shown in the accompanying sketch was designed, built, and used at the Michigan College of Mining and Technology. With a suspension of fine galena in water specific gravities up to 3.5 have been obtained without upward currents, and with a controlled rising current this amount can be increased considerably. In the latter case calibration of the control valve is necessary to obtain the desired specific gravity.

The sketch shows the essential features of the apparatus. It consists of a rectangular tank with one sloping end to facilitate removal of floats and to control the circulation of the suspension. This circulation is accomplished by a small centrifugal pump with a valve in the discharge for controlling the rate. The pump intake is under the screen on the sloping end, and discharge takes place through a perforated pipe in the bottom of the main part of the tank. The holes in the pipe are so arranged that a uniform rising current is given to the suspension. When a larger apparatus is necessary, the bottom can be divided into sections for better control. About 4 in. above it are supports for a screen-bottomed tray to catch the sinks. On this rests a frame with a removable screen bottom to catch the floats. An 8- or 10-mesh screen is suitable, as particles finer than 10 mesh will not settle readily in ore suspensions.

The auxiliary apparatus consists of a tank for settling, storing, and mixing the suspension, screens for washing the products, and a calibrated scale with cup for obtaining specific gravities. For obtaining viscosities the funnel described by H. N. Marsh[1] is convenient.



Cross-section of sink-and-float machine

If a specific gravity of 3.5 is high enough for the purpose, the following method is used in making the test: The trays are placed in the machine and the suspension is put in. The circulating pump is started and the sample put in. Then the pump is stopped to permit free settling. The screen is then slipped into the bottom of the float tray and the floats are lifted out. The sink tray is then removed and the pump again started. A measured quantity of water is added to dilute the suspension to the next specific gravity. The floats from the first separation are placed in the machine, and this procedure is repeated until a sufficient number of fractions

[1] H. N. Marsh: "Properties and Treatment of Rotary Drill Mud." *Trans.* A.I.M.E. (1931) 92 Petr. Dev. and Tech., 234.

Table I—Results of Sink-and-Float Test on Copper Ore

	Cumulative Concentrate		Cumulative Tailings			
% Wt.	% Cu	% Wt.	% Cu	% Wt.	% Cu	Metal Recovery	Sp. Gr.
18.20	7.10	18.20	7.10	81.80	0.90	63.72	+3.20
9.82	5.10	28.02	6.40	71.98	0.33	88.42	+3.10
8.89	0.45	36.91	4.97	63.09	0.31	90.39	+2.90
20.36	0.35	57.27	3.32	42.73	0.29	93.91	+2.80
34.90	0.30	92.17	2.16	7.83	0.24	99.07	+2.70
7.83	0.24	100.00	2.03	0.00	0.00	100.00	−2.70

Table II—Results of Sink-and-Float Test on Iron Formation

		Cumulative Concentrate		Cumulative Tailings			
% Wt.	% Fe	% Wt.	% Fe	% Wt.	% Fe	Metal Recovery	Sp. Gr.
25.34	38.70	25.34	38.70	74.66	26.84	32.87	+3.20
27.68	35.40	53.02	36.97	46.98	21.79	65.70	+3.00
9.82	30.20	62.84	35.92	37.16	19.57	75.65	+2.95
15.60	26.20	78.44	33.98	21.56	14.77	89.34	+2.85
10.61	17.90	89.05	32.07	10.95	11.74	95.77	+2.77
3.32	17.10	92.37	31.53	7.63	9.40	97.61	+2.72
7.63	9.40	100.00	29.84	0.00	0.00	100.00	−2.72
100.00	29.84						

have been obtained or everything sinks in the suspension.

If specific gravities greater than 3.5 are desired, the separation is made with the circulating pump running. By this method the effective specific gravity can be increased considerably.

The viscosity of the suspension limits this method to sizes coarser than 10 mesh for most minerals. Minus-10-mesh material, however, can be tested by the other methods mentioned.

Table I gives the results of a test on a sample of copper ore whose pieces averaged 2 in. in diameter. The test was made to determine the feasibility of discarding part of mill feed at this size. Table II gives the results of a test on a sample of iron formation whose pieces averaged 1½ in. in diameter.

This type of apparatus is useful not only in the laboratory but in industry as well. It can be used to replace hand picking at the mine and to eliminate coarse tailings early in the milling operation. In mine sampling, especially, where the values are irregularly distributed, it offers a quick method of obtaining information about the distribution of minerals encountered.

Ore Genesis At Meadow Creek Mine

H. D. Bailey

Goodsprings, Nev.

MY PRIMARY OBJECT in writing this article is to develop certain rules and theories of oreshoot control and ore genesis that will be of practical value in predicting the nature and position of orebodies at the Meadow Creek mine, in central Idaho. The deposit known carries antimony and gold and displays unusual mineralogic and structural relations, which demand unusual explanations.

The Meadow Creek mine is situated in Valley County, 80 mi. by road northeast of Cascade. The postoffice is Stibnite, mail service being by airplane during the winter. Along with other antimony deposits in the district, it was probably discovered about 1902 by prospectors from the old Thunder Mountain gold camp, 15 mi. east. Apparently its gold content was not suspected at the time. No development was done until 1919, when it was acquired by the United Mercury Mines Company. It was leased to the Yellow Pine Company, the present operators, in 1927.

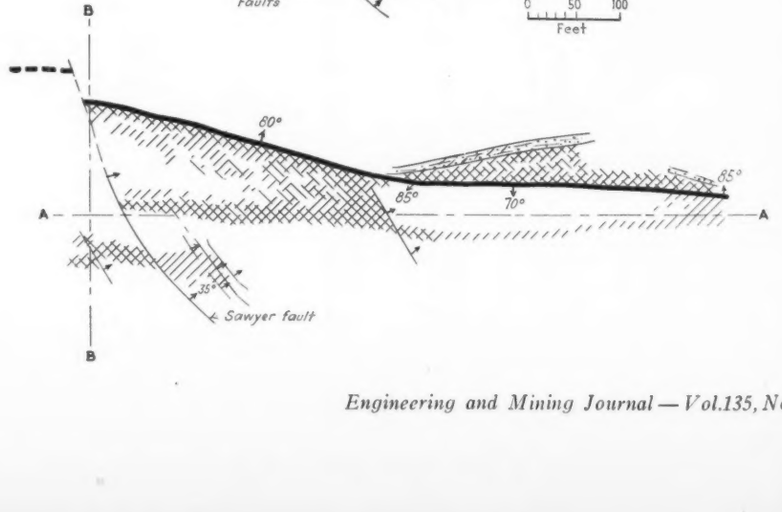
The known Meadow Creek orebodies are found along the eastern side of an extensive north-south shear zone, several hundred feet wide. The country rock is normal biotite-granodiorite of the Idaho batholith (Cretaceous), through which dikes and irregular bodies of aplite and pegmatite are complexly intruded. In some parts of the mine there is more aplite than granodiorite. The shear zone roughly parallels the intrusive contact with a series of metamorphosed sedimentary beds (Cambrian?), overlain, 5 mi. east of the mine, by the Thunder Mountain lava flows of Tertiary age.

Intimately associated with the ore in the eastern part of the shear zone are several kersantite (lamprophyre) dikes, or possibly faulted segments of what was one dike. They average 5 ft. in width and dip steeply east or west. Except where altered or mineralized they are gray green in color and have a finely crystalline, diabasic texture. The principal constituents are labradorite feldspar, biotite, olivene, apatite, and magnetite (10 per cent), with the secondary minerals, serpentine, chlorite, and calcite, well developed. As the aplite and pegmatite represent an acid differentiate from the parent batholithic magma, these dikes probably represent a later basic differentiation.

The central portion of the zone is lightly mineralized and often highly altered and fractured. This condition grades into a wide, well-developed fault, post-mineral in age. Between the fault and the granodiorite on the west is a rhyolite dike about 40 ft. wide. From its lithologic resemblance to some of the Thunder Mountain flows it can be referred to that activity. Farther north in the shear zone andesite dikes are known which complete the Tertiary intrusive evidence.

The metallic minerals include, in the order of their abundance, stibnite, pyrite, arsenopyrite, marcasite, and an unidentified silver mineral. Near the surface thin films, on stibnite, of kermesite (Sb_2S_2O) and various white and yellow oxides are found. Two distinct and separate mineralizations are manifest. The first consisted of microcrystalline quartz, filling fractures in and replacing the country rock; followed by pyrite and arsenopyrite and later gold. The sulphides were disseminated irregularly through the altered rock and fractured quartz. For much of the ore a fairly constant ratio of 0.5 oz. of gold to 1 per cent of arsenic has been noted. The gold is apparently associated with the arsenopyrite, upon which it was probably deposited in the same manner as in other gold deposits. The principal difference in this case is one of scale.

Geology and mineralization on two levels of Meadow Creek mine. The bottom level is 200 ft. below the upper, but in same relative position



Many of the arsenopyrite crystals (and also pyrite) can be seen only under the microscope, and no gold particles have been positively identified, even with high magnifications.

At some later time, certainly after much faulting, there was a second mineralization. Stibnite was the principal mineral introduced, along with chalcedonic quartz and some pyrite and marcasite. Several carbonates have been noted, principally calcite, which are earlier than the minerals mentioned and which may belong to the first mineralization. The fracturing of the quartz veins of the first period made them a favored place for stibnite deposition and replacement. Small stibnite-quartz stringers are found in the altered granodiorite and in most of the gold orebodies formed from this rock. In a general way this mineralization tends to concentrate near the top or north end of an oreshoot.

Probably the best proofs of these separate mineralizations are the underground and field relationships. Only one other antimony deposit in the district contains gold and associated sulphides, and it may be located on the Meadow Creek shear zone. Countless fissure veins and lens-shaped bodies occur, however, containing only stibnite and quartz. They may have some silver, but rarely more than a trace of gold. In the mine some orebodies show only one mineralization. The existence of fragile stibnite crystals, up to 2 in. in length, lying normal to the walls of open fault fissures, shows the relative lateness of at least the last phase of the antimony period. The slightest movement along these faults, many of which are definitely post-gold, would have destroyed these crystals.

Metallurgical practice at this property depends, to a great extent, upon a differential flotation of stibnite and the iron sulphides. Theoretically it would be possible to make an antimony concentrate with no gold or iron sulphides and most of the silver, and an iron concentrate containing no stibnite and up to 8 oz. of gold. The mineralogic relationships are manifest.

The trend of the orebodies as well as the dikes and many of the faults is north and south with the shear zone. Some of them are veinlike in appearance and connect with others. Others are irregular in shape and more or less isolated. Recognition of the structural elements which have controlled oreshoot formation is of paramount importance. Although other factors may be operative and others may become important, only two are considered.

Two types of faults and fractures, one striking east and the other about N. 30 deg. E., and both dipping from 25 to 45 deg. north, were effective in controlling ore solutions. They developed before the kersantite, but most of the movement took place after this intrusion and before mineralization. However, in at least two instances extensive post-mineral movement is shown (Sawyer Fault). The most important occurrence is known as the Hampton Fault, although it consists of a number of faults, arranged *en echelon*. The orebody which these faults control is irregular in outline, owing to the varying success the individual faults had in stopping the upward movement of the solutions. The change from ore to altered granodiorite is very definite, however, except on the west side, where later faulting has allowed some ore to re-form along a basic dike segment. In some cases this type of structure has developed orebodies which show only traces of the second mineralization.

The other important ore-controlling structure is the kersantite dike or dikes. A thin section of a specimen taken where the dike was fractured by the Hampton faults gives the following sequence of events: (1) Intrusion. (2) Brecciation. (3) Gold mineralization. (4) Alteration. (5) Brecciation. (6) Carbonate. (7) Stibnite. There existed, then, prior to mineralization, a tough, impervious, and practically unfractured unit in a fractured and altered host rock. Mineralizing solutions naturally followed along this dike, so that the position and size of many of the orebodies are directly attributable to the direction and degree of the dike's dip.

Two rules may be formulated. The dike is generally the hanging wall of an orebody, east or west. The size of an orebody usually increases as the dike's dip decreases. Some of the orebodies extend above or north of a reversal in dip and on some horizons may be some distance away from the dike, but for lack of a controlling structure they soon lose size and value.

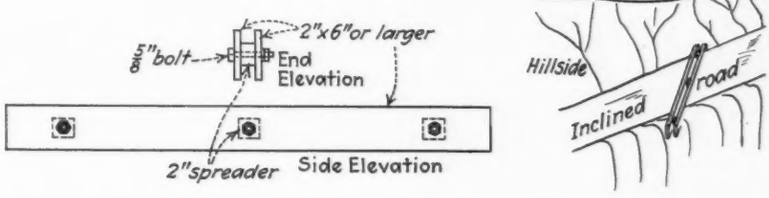
More than usual importance is to be accorded the genesis of the Meadow Creek ores. Larsen and Livingston[1] concluded that the near-by cinnabar deposits were related to the Thunder Mountain volcanics, and because of the presence of both cinnabar and stibnite in some deposits regarded the latter as having the same origin. Ross[2] discusses the genesis of the antimony deposits in considerable detail and likewise concludes that both types of deposits are related to the Tertiary dikes of the district. He also tells of Cretaceous lead-silver deposits (Wood River district, Idaho), which contain antimony minerals that may have been formed during a separate and later period of mineralization. The second or antimony mineralization at Meadow Creek mine seems to be definitely related to the Tertiary dikes. The first or gold mineralization is older than the Tertiary dikes and apparently related to a basic satellitic dike of the Idaho batholith.

Available evidence seems to show then that here occurs a Mesozoic mesothermal deposit which has been reopened to a Tertiary epithermal mineralization. From a practical standpoint the latter may be expected to disappear with depth beyond which the original ore should continue with little change.

[1]Larsen, E. S. and Livingston, D. C.: "Geology of the Yellow Pine Cinnabar District, Idaho." U. S. Geological Survey Bulletin 715, pp. 73-83, 1920.

[2]Schrader, F. C., and Ross, C. P.: "Antimony and Quicksilver Deposits in the Yellow Pine District, Idaho." U. S. Geological Survey Bulletin 780, pp. 137-167, 1925.

Protecting Inclined Roads From Washouts



INCLINED ROADS to a mine pit or on a sidehill are often damaged by heavy rains, writes Charles Labbe, Death Valley, Calif. Run-off water follows the two wheel ruts and takes along most of the binding material, leaving large rocks uncovered.

Several inexpensive methods may be employed to prevent such damage. For instance, if possible, the road may be made a little wider for a drain on the hillside and an iron pipe buried at intervals across the road to take the water to the lower side. Another method, just as simple but more efficient, is to bolt together two pieces of 2x6-in. timbers, using about three 2-in. blocks as spreaders, as shown in the accompanying illustration. The timbers joined in this manner are then sunk in the road at an angle with it and well tamped in place, the hillside end being placed higher than the other. This method is more efficient than a drain ditch cut into the road. As the timbers are narrow and solid, they are not felt by the traffic. Moreover, in a heavy rain the whole width of the road is drained, affording protection to the lower part.

MEETING THE DEMAND FO

Two Plants . . . in Arizona and

Mining and Processing This Non-metallic at Camp Verde, Arizona

A. J. McDermid

Mining Engineer, Miami, Arizona

Washing and drying plant of the Arizona Chemical Company

THE sodium sulphate mine operated by the Arizona Chemical Company, a subsidiary of American Cyanamid, is in the valley of the Verde River, near Camp Verde, Ariz. The sulphate is contained in a 4½-ft., flat-lying bed which outcrops along the west side of the river valley and is a member of a thick series of sediments consisting chiefly of clays, sodium chloride, sodium sulphate, and calcium sulphate. Lack of vegetation in the immediate vicinity of the camp and the nature of the soil recall accounts of the Chilean nitrate fields. The sulphate is hard on the hair, skin, and clothing, and the workmen park their automobiles out of reach of the dust from the washing plant to protect the finish.

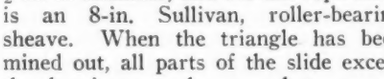
In the mine, which is entered by a tunnel, the ore is cut up by drifts into blocks 100 ft. square, which are mined out in open stopes. The ground stands so well that stulls and a few small pillars will support the back of a block until it is mined out. Most of the drifts are untimbered. Stoped ore is mucked by means of a Sullivan triple-drum hoist and a hoe-type scraper and a slide, operated by a 20-hp. Fairbanks Morse motor. Only two drums of the hoist are used.

The construction of the slide is interesting. It is built of timber, at a drift intersection, so that the scraper can operate on the triangular-shaped piece of ground formed by the halves of two adjacent 100-ft. blocks, as shown in the accompanying sketch. The slide, situated at the apex of the triangle, is about 25 ft. wide at the widest part where it rests on the floor of the stope, and converges to an opening at the loading drift, where the scraper's load drops into 1.1-ton capacity cars. The foundation is made of 8x8-in. stringers resting on round posts. A layer of 2-in. plank is nailed to the stringers, and across the plank, in the direction the scraper is to run, are nailed ⅜x2-in. steel strips, spaced 8 in. apart. The hoist is set up across the loading drift from the slide. The ⅝-in. wire pull rope passes through a 10-in. Sullivan, roller-bearing sheave suspended over the opening in the slide. The tail rope is ½ in. in diameter, and the tail-rope block is an 8-in. Sullivan, roller-bearing sheave. When the triangle has been mined out, all parts of the slide except the lagging can be moved to a new location, to be set up and used again. The worn lagging is used for mucking floors and miscellaneous purposes.

Drilling in the drifts and stopes is with Cochise pluggers. The compressor, a two-stage, Type XRB Ingersoll-Rand, is set up in the mine and is capable of supplying air for eight machines. The ore is hauled out of the mine by mules to a 200-ton bin.

Ore from the bin is first washed in a cylindrical screen washer made by the Weller Manufacturing Company, of Chicago. It is 25 ft. long; the first half is 6 ft. in diameter and the other half is 4 ft. The screen is 5 mesh. In the washer the rock meets a spray of water which washes the clay and sodium chloride through the screen. The washed sulphate is dried in a 9x50-ft. steel cylinder, made by the Standard Boiler & Steel Works, which is set up at a slight slope so that the rock gravitates toward the discharge end as the drier is revolved. For heat, fuel oil is burned in a burner in the upper end of the cylinder. A blower draws the heat through the drum and also picks up waste particles which arise as a dust as the cylinder revolves. The drier was used for drying kelp in a previous installation.

Sketch showing position of slide



The dried sulphate is crushed to ¼-in. size in a set of 20x30-in. Traylor rolls, driven by a 30-hp., 440-volt Fairbanks-Morse induction motor. The crushed ore is transported to storage bins by a Link-Belt screw conveyor. Electric power is supplied to the property by the Arizona Power Company, over a transmission line from the power plant at Clarkdale. Most of the motors used are Fairbanks-Morse units.

A typical analysis of the finished product is as follows: Insoluble, 2.68 per cent; $CaSO_4$, 1.63 per cent; NaCl, 0.55 per cent; Na_2SO_4, 95.14. The principal use of salt cake, as the washed product is known, is in the manufacture of paper. It is also used as an ingredient of stock and poultry feeds. During 1925 some prehistoric stone hammers were found embedded in the deposit at a depth of 65 ft. below surface.

From the storage bins the salt cake is hauled in four 2½-ton Mack trucks, built up to hold 7 tons, to the rail head at Clemenceau. The mine is worked on three shifts and the washing plant intermittently on day shift. The operating crew consists of 70 men, under the supervision of W. L. Powers.

FOR SODIUM SULPHATE

and Utah . . . Contribute

Salt Lake Company Working Bed of Glauber Salt

Gail Martin

Special Correspondent, Salt Lake City, Utah

Plant of Salt Lake Sodium Products Company

MANUFACTURE of anhydrous sodium sulphate from a bed of glauber salt lying along Great Salt Lake 16 miles west of Salt Lake City has been started by the Salt Lake Sodium Products Company. The pilot plant has been designed to produce 25 tons daily of this substance, used in the manufacture of kraftpaper, heavy chemicals, silk rayon, textiles, glass, soap, medicinals, and other allied products. Sufficient room has been provided in the pilot plant for doubling its capacity by installing additional machinery.

The company controls 700 acres of lake bottom under which a bed of glauber salt, 2 to 30 ft. thick, extends over the entire acreage, with an overburden of clean lime sand 18 in. to 4 ft. thick. The crude glauber salt as mined has the average analysis given in Table I.

The water-insoluble sands showed the screen test recorded in Table II.

Individual particles of this sand are spherical. Analysis of the water-insoluble sands assay is given in Table III.

After dissolving soluble salts with water, the decanted solution assayed as shown in Table IV.

The crystallized Na_2SO_4 from the evaporator contains 99 to 99.5 per cent $NaSO_4$, 1 to 0.5 per cent NaCl, traces of water-soluble iron, calcium, magnesiuum, and no H_2SO_4. The aqueous solution made from the anhydrous sulphate has a pH of 8.

Mining of the crude glauber salt will be done in open pits. Instead of ordinary drilling, holes will be melted out for blasting by using a steam pipe connected to a portable steam boiler. This system of drilling has been proved cheap and efficient by power and telephone companies in putting down for poles and also by the Saltair Beach company in placing piles for the dancing pavilion and bathhouses for the Saltair resort, about a mile distant.

Blasting will be a matter of experiment. When broken, the mineral will be loaded into dump cars by scrapers or dragline and hauled to the receiving end of an inclined-belt conveyor, which will deliver the crude ore into two 50-ton steel bunkers. The ore will enter the mill on a feed belt.

Refining will be done by the hot process, which consists essentially of dissolving the glauber salt in hot water, diverting the sand, and then leaching and evaporating the solution. Steam is supplied by a Stirling boiler and the power for the machinery and the exhaust steam for the evaporator by a Corliss engine and a Ball engine.

Crude ore is fed from the storage bunkers into a steam-jacketed mixer, which delivers the product into a 45-in. Akins classifier, where the sands are eliminated and conveyed by launders to the tailings pond. These sands, which are high in calcium carbonate, may be utilized by local smelters in smelting ores.

The solution from the classifier is heated, filtered, and pumped to surge tanks in the upper part of the mill. From these it flows into a forced-circulation type of evaporator, the heaters being separate from the evaporator flash tank and heated by exhaust steam.

Anhydrous sulphate crystals are pumped from the evaporator into a settling tank over a 40-in. centrifugal machine, where most of the water is eliminated and the crystals are washed with clean water. From this machine, the salt is fed into a steam-heated rotary dryer and finally elevated into 200-ton storage bins.

Officers of the company are Fred W. McEntire, president; H. S. Tucker, vice-president; and Arthur Erickson, secretary-treasurer. These with J. D. Shilling and H. Eugene Glenn comprise the board.

Table I—Analysis of Crude Glauber Salt

	Per Cent by Weight
Na_2SO_4	22.39
NaCl	1.53
$CaCl_2$	0.11
$MgCl_2$	0.47
Water insoluble	45.70
Water of crystallization	26.70
Moisture	2.80
Total	99.70

Table II—Screen Test of Water-Insoluble Sands

Mesh	Individual	Cumulative
Plus 20	0.2	0.2
Minus 20 plus 40	1.3	1.5
Minus 40 plus 60	19.4	20.9
Minus 60 plus 80	11.0	31.9
Minus 80 plus 100	31.6	63.5
Minus 100 plus 120	6.0	69.5
Minus 120 plus 150	21.4	90.9
Minus 150 plus 200	4.1	95.0
Minus 200	1.4	96.4

Table III—Analysis of Water-Insoluble Sands

Insoluble Sands	Per Cent of the Insoluble
Acid-soluble Al_2O_3	1.0
Acid-soluble Fe_2O_3	0.6
Acid-soluble $CaCO_3$	68.0
Acid-insoluble residue	25.0
Organic matter	4.4
	99.0

Table IV—Analysis of Soluble Salts

	Grams/C.C.
Na_2SO_4	0.3375
NaCl	0.0349
$CaCl_2$	0.00165
$MgCl_2$	0.00710
pH	8.2
Insoluble	0.0022

ANSWER TO ALABAMA GRAPHITE PROBLEM

Lies in Lower Cost Methods of Preparing Product

B. W. Gandrud and G. D. Coe

Supervising Engineer and Cooperative Junior Chemical Engineer, Respectively, Southern Experiment Station, U. S. Bureau of Mines

THE graphite-mining industry of Alabama is an outstanding example of war-time industrial expansion and inflation and post-war deflation. As a result of the war boom, at least thirty plants for the mining and preparation of graphite were completed in Alabama. From 1920 to 1930 graphite prices declined more or less continuously, gradually forcing the shutdown of all such mines. In 1918, according to Ferguson[1], "flake graphite containing about 90 per cent of graphitic carbon sold for prices ranging from 15 to more than 18c. a pound, and the graphite containing 85 per cent of graphitic carbon, which formed the bulk of the output, sold at 10 to 15.5c.—probably the greater part at 14 to 15c. a pound." Middleton[2] stated, "The general average value of domestic crystalline graphite was 3.5c. per pound in 1930, as compared with 4.6c. per pound in 1929." At this price Alabama operators could no longer produce graphite at a profit.

It seems improbable that a return to normal business conditions will cause very extensive improvement in the price of graphite, which is governed to a great extent by the value of the imported product. Therefore, if the Alabama operators are to revive their industry, they must find a way to reduce production costs, making profits possible at prices not much above those of 1930.

With this situation in view, the Southern Experiment Station of the U. S. Bureau of Mines, in cooperation with the University of Alabama and certain mine operators, undertook to develop methods for simplifying the flowsheets formerly used in preparing graphite from Alabama ores. This investigation was completed in 1933, and the results have been described in detail in U. S. Bureau of Mines Report of Investigations 3225. The most significant factor brought out was the importance of controlling the acidity of the graphite flotation circuit.

Before 1915, various methods of preparing commercial graphite from Alabama ores were studied, including "surface tension" or "skin" flotation. From 1915 to 1919, froth flotation became a well-established practice in the graphite districts of Alabama, Texas, New York, and Canada. Few, if any, significant changes have been made since then in the design of the plants or in the selection of reagents. In Alabama, the use of pine oil and kerosene as flotation reagents, without any control of the acidity and alkalinity of the pulp, was more or less standard practice.

Results of Single-Stage Flotation of an Alabama Oxidized Graphite Ore

Test No.	Quantity of Reagent, Pounds per Ton		Concentrate		
	Pine Oil	Sulphuric Acid	pH value	Carbon, per Cent	Recovery, per Cent
1	0.73	None	7.4	45.4	80.0
2	.73	2.0	5.0	75.1	77.1

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[1]Ferguson, Henry G.: "Graphite." U. S. Geological Survey, Mineral Resources of U. S., 1918, Part II, published 1921; p. 229.

[2]Middleton, Jefferson: "Graphite in 1930." U. S. Bureau of Mines, Mineral Resources of U. S., 1930, Part II, published 1931; p. 103.

[3]In studying the effects of pulp acidity and alkalinity, hydrogen-ion concentrations were determined colorimetrically at the completion of each flotation test. A pH value of 7.0 corresponds to a neutral pulp. As the alkalinity increases, the pH values increase above this figure, and as acidity increases, pH values decrease below 7.0.

The Bureau's tests showed that pine oil was the most satisfactory reagent for flotation of graphite ores when used with sufficient sulphuric acid to give an acid pulp. Oxidized ores, when ground wet, without the addition of acid or alkali, all produced neutral or slightly alkaline pulps. The tabulated results of single-stage flotation of one of the oxidized ores are typical and illustrate the effect of pulp acidity[3] on flotation.

No difficulty was experienced in obtaining concentrates of commercial grade from all of the ores that were investigated, using two-stage flotation of an acid pulp in cells of the mechanical-agitation type. The ores were ground in a laboratory rod mill until all of the gangue passed a 65-mesh screen, although most of the graphite was too coarse to pass this screen. Primary flotation concentrates were reground for 15 min. and then refloated.

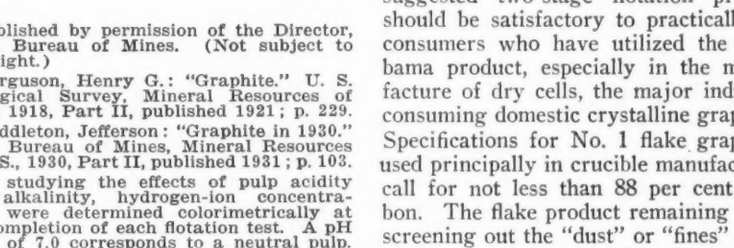
The five oxidized ores investigated gave final concentrates analyzing 85.6, 84.8, 87.3, 84.1, and 95.9 per cent carbon, respectively. Formerly, to obtain concentrates of this grade, complicated flowsheets were employed. These involved three or four stages of flotation and several stages of final screening, with intermediate buhr-mill grinding.

The concentrates produced by the suggested two-stage flotation process should be satisfactory to practically all consumers who have utilized the Alabama product, especially in the manufacture of dry cells, the major industry consuming domestic crystalline graphite. Specifications for No. 1 flake graphite, used principally in crucible manufacture, call for not less than 88 per cent carbon. The flake product remaining after screening out the "dust" or "fines" from the concentrates resulting from these tests analyzed over 88 per cent carbon.

Relieving an Airbound Pump

REDUCTION in pumping capacity and ultimate failure were experienced recently at Empire Mines, Grass Valley, Calif., after the 5-in. suction line of a large multi-stage centrifugal pump had been replaced with one measuring 6 in., writes Phil Keast, general repair man.

Investigation as to the cause of this unsatisfactory operation showed that the 5-in. pipe attached to the suction end of the pump was airbound, owing to the air trap formed in the 6-in. ell. The difficulty was overcome by providing the ell with a small petcock.



SILICOSIS

Pathological Aspect of Causation—Determining the Disease

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RESEARCHES of many pathologists show definitely that some form of the chemical molecule silica (SiO_2) produces the peculiar fibrous growths and nodulations in the lung tissue which are the indications of the disease silicosis which proves so dangerous to men in some industrial occupations. It is, however, an open question whether compounds of silica with metals (that is, silicates) may not liberate their silica and so produce the same disease as the free silica (quartz) does. Certainly, chrysotile asbestos, the hydrous magnesium silicate, has been found to produce a somewhat similar if not identical disease. Dr. W. R. Jones makes a strong case for the similar inclusion in this category of the mineral sericite, a hydrous potassium aluminum silicate, and Dr. Charles Badham, of New South Wales, also includes the mineral sillimanite, aluminum silicate. Dr. Badham coins a new word, "silicatosis," to name the lung disease produced by silicate minerals to correspond with "silicosis," which has been blamed solely upon "free silica." Inasmuch as the silica molecule is probably responsible for any toxic effect, whether free or bound, it would seem simpler to expand the meaning of the well-known word "silicosis" to include silicates which produce similar effects, but legal definitions must then be changed.

Theories

Many different theories have been advanced and revised in an attempt to explain just what influence a silica particle has upon the cell structure, and the whole question is complicated by the many diverse answers. Perhaps there is reason to assume that many of the theories answer the question in part but not fully, in so far as any one theory alone is concerned. Thirty years ago it was thought that the injury to the lungs by a silica particle was of a purely mechanical nature and that the sharp mineral fragments penetrated the lung tissue and encysted there (just as a splinter would in your finger), and thereby proved a source of inflammation and a growth of scar tissue which impaired the functions of the lungs. That some such effect may still be present seems plausible, but not in a sufficient degree to cause the serious impairment which results in silicosis; and, too, further researches have proved that toxic effects are produced by silica. Great emphasis used to be placed upon the "blocage" (plugging) of the lymphatic vessels of the lungs by dust-laden cells, particularly at the lymphatic nodes, with a consequent fibrous growth due either to poor lymphatic circulation or some strange local influence of such dust-laden cells. South African researchers (Dr. Mavrogordato and others) proposed that the silica formed a sort of waterglass (hydrous sodium silicate) which virtually mummified the dust-laden cells and thus gave rise to a fibrotic induration. Other investigators have suggested that the surface of a silica particle adsorbs water from the protoplasm of the phagocyte and so inhibits its normal functions, or else claim that a silica gel is formed which either acts in that fashion or affects the colloidal properties of the protoplasm. Another theory is advanced that a yet unanalyzed organic-silica colloid is formed in the protoplasm and that its influence spreads to neighboring cells to produce a fibrous structure of connective tissue.

Whatever may be the facts as to the theories and assumptions outlined in the foregoing, the work of a number of experimenters who have injected silica sol (orthosilicic acid), sodium silicate, or silica particles into the various tissues of animals has shown that silica is toxic and produces the same type of fibrotic growths in their lungs as in "silicosis." They also speak of "occult" silica which comes from solution and is invisible or else is in particle sizes too small to be seen in the lung tissue, although recoverable as microscopic particles from such tissue.

Dr. Gardner states that quartz particles are ingested slowly and are toxic in effect, accelerating the migration rate and then killing the cells which ingest them, thereby liberating the remaining silica particles, which are then progressively ingested by new phagocytes. The migratory phagocytes, with great activity because of the irritating effects of the silica, carry their particles into the connective tissue, where they react with those cells and by mitotic proliferation (subdivision) produce a fibrous multi-nucleated cell structure in appearance like that due to tuberculosis but not containing visible dust; but some phagocytes containing silica may show intervening. After a few months, a dense and heavy structure of closely packed spindle-shaped cells and numerous giant cells may show. After a year, approximately, the cytoplasm of these cells may swell and their nuclei compress or disappear in this degeneration, hyaline forming in the connective tissue which is in concentric layers (a pseudo-tubercle). Thus the silicotic nodules are formed. He also states that a so-called acute form of silicosis can develop within a period of twelve to eighteen months where the atmospheric concentration of silica is extremely high.

The silicotic condition greatly increases susceptibility to tubercular infection and it intensifies and accelerates the formation of fibrotic tissue, so that it is said that over 75 per cent of silicotics die of tuberculosis. Also, a tubercular condition increases the susceptibility to silicosis, and a syphilitic condition does likewise. In a test tube the addition of silica promotes the rapidity of growth of tubercle bacilli. In living tissue silica indicates a similar effect. The nature of its influence is not truly understood, but it has been proposed that the colonies of tubercle bacilli are so encased by the silicotic tissue as to prevent the leucocytes from successfully attacking the bacilli, which can therefore better proliferate. Pneumonia and other lung infections are more likely to be established and prove fatal with silicotics than with normal persons.

Other Mineral Dusts Than Silica

We have noted that silica stimulates the movement of a phagocyte and so it ingests but few particles and travels far.

When most other mineral dusts are ingested, the phagocyte has a tendency to gather particles of dust until it can hold no more, and so it becomes heavy laden and its power of locomotion becomes limited. Therefore, the particles are not moved from the air spaces where they penetrated but are taken up by new phagocytes when the old ones die and disintegrate. Less heavily laden cells make their way either through the surrounding tissue or along the walls of the air spaces until they reach the peripheral ends of the lymphatic vessels, which they penetrate.

Silicon carbide (carborundum) tends to be held in the air spaces more or less

Other articles on silicosis have appeared in the January, February, and March issues.

indefinitely; much of the granite dust is also retained in place, but some reaches the lymphatic system; coal-containing cells migrate more rapidly; asbestos fibers, because of their greater length, are not to a great degree inhaled into the terminal alveoli, but lodge on the cilia-free corrugated surfaces of the bronchioles, and they are engulfed by giant phagocytes, which usually carry them directly into the walls of the bronchioles and not into the lymphatic system.

Five Phases

Dr. Gardner accordingly recites five phases by which mineral dusts are disposed of by the phagocytes and the corresponding pathology:

"1. Early diffuse parenchymatous (jelly-like connective tissue) disease due to accumulation of phagocytes and local inflammatory changes in the immediately adjacent connective tissue.

"2. Linear perilymphatic proliferation (fibrotic cell growth around lymph channels).

"3. Beading of the trunks (lymphatic trunks) due to chronic proliferative changes in associated lymphoid tissues.

"4. Enlargement of the mediastinal (middle chest) lymph nodes due to proliferation of the local connective tissues.

"5. Late chronic proliferation and nodule formation in the finer connective tissues of the pulmonary parenchyma (organic tissue of the lung)."

Silica produces all these stages; pure fibrous asbestos produces the fibrotic growth of (5) but no nodules; silicon carbide produces (1) and (2) in experimental animals; coal with very little silica gives (2) and a little fibroid tissue (5), but no nodules; Barre granite showed predominately (2) but with tuberculosis showed (5).

The asbestos fibers are ingested by giant cells and form peculiar long cells, sometimes nobbed at the ends and sometimes beaded, with a ferric iron stain, called "asbestos bodies."

The lungs of infants are pink in color; those of adults are a slate blue because of the pigmentation from phagocytes carrying carbon particles from the smoky air we all breathe; and the lungs of coal miners are black from the coal-dust pigmentation. However, pigmentation does not entirely incapacitate our vital processes, because there is so great a reserve capacity in the functions of the lungs when morbid tissue does not disturb it.

Determination of the Disease

In the diagnosis of silicosis the following factors should be considered:

1. The age and past health history of the individual (tuberculosis, bronchitis, pneumonia, asthma, syphilis).

2. The dust conditions under which he has worked and lived (mineralogical character, particle sizes, length and severity of exposure, dates of exposure).

3. His present health condition (shortness of breath, dry cough, chest pains, fever, susceptibility to colds, blood-spitting, night sweats, loss of weight, increased pulse).

4. Physical examination (reduced vital air capacity, expansion and elasticity of chest, listening to sounds in lungs, resonance of chest to tapping, configuration of chest).

5. Laboratory examination of body fluids, secretions, and excreta (sputum, blood, spinal serum, nasal discharges, urine, and foecal matter).

6. X-ray observations of the lungs (indications of fibrous scar tissue in the lungs in branching or mottled patterns, opacities of pleural thickening and nodules, observation of lesions in the lungs, matting together of nodules into irregular asymmetrical areas of induration, dilation of the heart).

On the basis of diagnosis silicosis is classified as either simple silicosis or silicosis combined with tuberculosis. In simple silicosis the disease is arbitrarily decribed as being in one of three stages of development—first, second, or third stage. In South Africa and in Ontario these three stages are called, respectively, anteprimary, primary, and secondary.

In the first stage, the symptoms are few and often indefinite: slight shortness of breath on exertion, some unproductive cough, less chest expansion than formerly, and radiographic findings of generalized arborization patterns through both lungs with some discrete mottling. The general appearance of health may be excellent and working capacity is not noticeably impaired.

In the second stage, a definite shortness of breath is found, chest pains are frequent, as well as colds, and a dry morning cough is common, a definite decrease in expansion and elasticity of chest is noticeable, but appearance and weight may be healthy. The X-ray pictures show a generalized, medium-sized mottling throughout both lungs, and individual nodules (occasionally aggregated) show on a well-defined background of fibrous arborization. The capacity for work is hampered but not destroyed.

The third stage shows distressing shortness of breath upon only slight exertion, a frequent cough, expectoration, serious impairment of working capacity, greatly reduced vital lung capacity and expansion, loss of flesh, increased pulse rate, and a dilated heart. The mottling shows more intensely in the X-rays, and larger nodules and areas of fibrotic growth are shown by their shadows. Permanent and serious incapacity for working results. Tuberculosis is often involved, and it may be associated with the earlier stages of the disease.

Diagnosis of silicosis is far from being a simple, definite procedure, for it requires a great deal of special experience as well as instruction. The symptoms of shortness of breath, dry coughs, and the like may result from many other causes. Tuberculosis may be present and yet inspection of the sputum may fail to shows its bacilli. An individual's imagination may subconsciously cause him to simulate shortness of breath and other symptoms. Percussion and auscultation (listening by stethoscope) may easily result in making incorrect interpretations.

Even X-ray determinations may be in error. The correctness of photographic exposure is highly important and sensitive; and inasmuch as it involves many variables a special technique, training, and experience are essential, or else the radiographs will be misinterpreted. Some of the important factors in taking pictures are: current and voltage supplied to the X-ray tube, nature and condition of that tube, length of exposure, centering of the beam of X-rays in the correct relative position to the human chest, mounting of the photo-sensitive film normal to the beam and at a sufficient distance (five feet or more) from the source of X-rays, correct film emulsion to assure fine grain structure and resolution of detail, contrast, and correct exposure, correct posture of the subject for anterior, posterior, and lateral views, determination of the depth of the chest and estimates of the amount and quality of the covering flesh on chest and back. It is said that an under-exposed film may be mistakenly interpreted as showing silicosis when that disease is not present, and that an over-exposed film may fail to show silicotic conditions which are present.

Possible Errors

Many other pathological conditions may be wrongly interpreted as silicosis by diagnosticians without either sufficient experience or without contributory evidence of case histories and laboratory findings. For example:

1. Tuberculosis and silicosis in some stages are very hard to differentiate, especially when the tubercle bacillus does not show.

2. Acute bronchial infections of the capillary type may exist, bronchial catarrh, and acute or chronic injury of the respiratory passages by certain gases.

3. Early stages of congestion from cardiac trouble, or congenital cardiac defects may be responsible for the apparent symptoms.

4. Lymphoblastoma, especially of the nodular type and in the hilus area, may be responsible for the patient's condition.

5. Inflammation of veins and arteries (periarteritis and periphlebitis) when they are in the lung field may exist.

6. Carcinomatosis of the miliary type, where cancerous cells have been car-

ried by the lymphatics or the blood stream and have been deposited in the lung field, may characterize the condition of the patient.

7. Other pathological conditions such as syphilis, leucaemia, septicaemia, sarcoid, granulomata, obliterating bronchiolitis, edema, and fibrosis from old age or prolonged X-ray irradiation treatments may be responsible for the symptoms exhibited.

Several Views Necessary

Often a single posterior X-ray view is not a reliable basis for diagnosis. Additional lateral or anterior views are necessary or stereoscopic films with stereoscopic viewing are required to give the perspective for a three-dimensional observation. A radiograph of the lungs is a shadow picture (silhouette) of cellular tissues of varying densities, structures, and contents, and the skeletal structure, stomach, liver, spleen, diaphragm, and heart mask certain portions in any one view. The Roentgen-rays come from the X-ray tube as a divergent cone, so that the projected shadow is enlarged and undergoes a lack of definition in proportion to the ratio of the distance of the tube from the lungs to the distance of the tube from the photographic film. Therefore the farther away the tube is from the subject, and the nearer the film is to the subject, the better the results should be. But the intensity of the X-rays varies inversely as the square of their distance from their source, so that the length of time for a correct photographic exposure varies directly as the square of such distance. However, the exposure must be short enough to avoid a blurred image from the motion of the tissues. The vibration of heart beats is transmitted to the lungs directly and through the blood stream even though an immobility of inspiration or expiration is possible, so that the exposure should be about 1/25 to 1/50 of a second for the best pictures of early pathological changes. With the highest-powered tubes pictures can be taken with the film 9 ft. away from the X-ray tube, but some claim that the results obtained do not warrant taking pictures at more than 6 ft. This may be a practical rather than an academic matter. Unfortunately, scientists have found no way to focus or make a parallel beam of X-rays.

At the recent annual meeting of the American Institute of Mining and Metallurgical Engineers an experienced roentgenologist, Dr. C. V. Kilbane, called attention to some of the difficulties of differential diagnosis mentioned in the foregoing, and said:

"I do not believe the roentgenologist, just in casting his eyes on the shadows on the film, has sufficient evidence to say such shadows represent a certain condition without assistance from the other phases of medicine," without "all the help he could gather from the record, the history, the physical findings, and other laboratory findings." He said that radiographically the various arbitrary classification stages (first, second and third) were not properly descriptive of the findings, so he concludes: "The classification of silicosis has not been final, the pathology of silicosis is not final, nor has the simplicity of roentgenological diagnosis been final."

At the same meeting a well known researcher in this field, Dr. Leroy U. Gardner, tempered any misconception or over-emphasis of Dr. Kilbane's remarks by the following comments:

"In the matter of diagnosis I feel that the X-ray is the mainstay. To the person who is seeing large numbers of X-ray films from workmen exposed to various dusts, these other diseases (the aforementioned confusing diseases which might be mistaken for pneumonoconiosis) do not offer the difficulties he would imply. Undoubtedly we will make mistakes, but I feel that in the large majority of instances we will be right in the interpretation of films. The technique as used at the present time is fairly well standardized; and, given *good films* and a proper history of exposure, it is my belief that we are in a position today to diagnose this condition quite satisfactorily once it has arisen."

In all fairness to Dr. Kilbane, inasmuch as limited quotations are often deceptive, we should note that his attitude was not that diagnosis of silicosis could not be made but, rather, that special expert experience was necessary in the taking of X-ray pictures of the lungs and in the diagnosis of the films, and that much accurate correlative information should be involved. Dr. Gardner's remarks were evidently in entire agreement.

We may note that the two principal essentials are: an accurate and complete case history of diseases and exposures, and properly taken and exposed photographs. The technique of taking the pictures involves judgment, the human element. Many methods and accessories have been developed for the determination and control of the exposure, but none which eliminates the factor of judgment. Uniformly satisfactory and standardized films will not be obtained until an advance has been made in that technique. It is suggested that the following new line of attack would hold the promise of accomplishment in this direction:

Proper Exposure

The proper exposure of the film depends upon its reception of a sufficient quantity of roentgen rays which have passed through a substance, so it represents an integration of roentgen rays. If a roentgen ray meter be invented and used behind the film a proper exposure could be assured. Such a meter could be either of an indicating nature (if it showed a cumulative effect) or it could be made to control relays which terminated the exposure. Since roentgen rays cause fluorescence, and, also, since they ionize gases, either or both of those properties could be utilized; and electronic tubes can well be employed as relays with electrical condensers as reservoirs which have definite capacities and then discharge when filled.

The present lack of definitely controlled methods for taking X-ray pictures of the lungs, and also the lack of definiteness in the interpretation of such pictures, is indicated by the recent experience of an industry which made an X-ray survey of its workmen. The resultant films were inspected independently by three experts who are world famous for their experience and special ability in that field. Their reports showed a wide difference in their estimates of the percentage of the films which they diagnosed as showing silicosis. This circumstance should not be construed as showing the ineffectiveness of X-ray diagnosis, but it should indicate the need and opportunity for advances in the technique of that field, and the almost certain errors which are likely to arise from the comparatively inexperienced "expert" testimony which can be expected in the widespread silicosis lawsuits throughout our country.

Dust Contents of the Lungs

Determination of the dust found in the lungs has always been of a post-mortem nature and possibly it will ever be so, but it would be highly desirable if methods could be devised to detect the presence of mineral dusts "in vivo" and also determine their nature. The chief difficulties involved in the use of X-rays for the determination of the contents of pulverized minerals are the much greater necessary concentrations of the dusts in contrast to their extreme dilution and dissemination in the lung tissue; and the high intensities of X-rays and the long exposures required in X-ray mineralogy, exposures destructive of human tissues and yet incompetent to avoid blurred images from the functional motion of that tissue.

For years the determination of the mineral contents of lungs has been limited to weighing it and making a chemical analysis of it. Often the lung tissue was incinerated and the ash analyzed, particularly for the determination of the silica, and a differentiation attempted of "free silica" (quartz) from the "combined silica" (silicates). But blood, serum, protoplasm, and tissue contain organic mineral salts and silica is one of the salts in solution, as well as salts of phosphorus, potassium, and sodium in high percentages. The presence of salts of phosphorus makes extremely difficult the determination of small quantities of the alumina which is likely to be present in rock dusts as an

aluminum silicate or as a hydrated aluminum. The body tissue, fluids, and protoplasm, besides containing carbon, oxygen, nitrogen, and hydrogen, also show variable minute amounts of the elements calcium, magnesium, sulphur, nickel, iron, zinc, manganese, arsenic, iodine and even titanium, vanadium, and molybdenum.

Amount Varies With Method

The amount of mineral residue varies greatly with the method of extraction, according to the report of Dr. F. W. Simson, of South Africa. The former method of Dr. J. McCrae (also of South Africa) was to dry the lungs to a constant, then consume them by fire in an oxidizing atmosphere, and ignite the ash. Dr. Simson slimed the tissue with fuming nitric acid and possibly removed a large quantity of soluble salts in the acid treatment. Dr. McCrae also digested the tissue with hydrochloric acid and potassium chlorate.

The method of subjecting the dried lung to the action of sulphuric and nitric acids without preliminary incineration (ashing) is tedious, cumbersome, and difficult of manipulation, so only small portions of the lung were usually used. The residue obtained consisted of the free silica in the lung, the silica which was liberated from silicates by the action of sulphuric acid, and the refractive silicates. From a small piece of lung the amount of insoluble residue was not enough for an accurate determination of its constituents.

King, as described in the 1928 *Journal of Biological Chemistry*, used nitric acid and ammonium nitrate to treat a small amount of dry lung tissue and extracted the residue with sodium hydrate and tested for color with ammonium molybdate, but he obtained by this process only a silica soluble in sodium hydrate and he also missed the silicates not decomposed by nitric acid.

To determine the silica, silicates, alumina, and alkalis, Mr. B. H. Taylor, of New South Wales, used Fresenius' method, using successively sulphuric acid, nitro-hydrochloric acid, hydrofluoric acid, and sulphuric acid again. To determine coal dust he digests the dried lung tissue in caustic soda and later neutralizes with nitric acid.

The most recent method of extraction is that proposed by Dr. W. R. Jones, the British geologist. His method, as given in the August, 1933, "Journal of Hygiene," of Great Britain, may be summarized as follows:

Wash lung and transfer to a 2 liter beaker (14 c.m. diam. x 19 c.m. high) and allow only a little of it to rest on the bottom of the beaker.

Add 120 c.c. strong nitric acid, and after 6 hr. add 120 c.c. more, and subsequently further additions until the whole lung is slimed in the course of seven to twelve days. Vigorous effervescence of carbon dioxide occurs from the action on the dried lung.

Pour 50 c.c. of slime in a 500 c.c. flask and filter through Whatman's No. 54 filter paper; wash, and refilter until it is freed of acid; then remove and dry in an oven. The solids are transferred to a platinum dish and gently heated in a fume-cupboard for 4 to 5 hr., then ignited; and the residue is the mineral in question.

Nitric acid does not attack silicate minerals as much as hydrochloric acid and is quicker in sliming the lung than sulphuric acid (used by some investigators) or hydrochloric acid. It also filters easier than sulphuric acid, but it oxidizes any ferrous iron to a ferric state. Minerals can also be settled from the slime by agitation in water.

All of these chemical methods of extracting mineral matter from the lung tissue would appear to be destructive of certain minerals; for instance, any limestone dust (calcite or dolomite) would go into solution because it is a carbonate compound. Incineration of the lung tissue has the disadvantage of consuming any carbonaceous dusts and also breaking down organic salts of the tissue to leave their mineral constituents. None of the methods would assure that the mineral particles were left in their natural size and form, and in some cases would change their composition, for the mineral residue is subjected to high enough temperatures to consume the filter paper.

One of the properties possessed by many minerals is decrepitation (flying to pieces when heated); and even quartz commonly contains bubbles of fluids or gases (water and carbon dioxide) whose expansion upon heating bursts the particle.

New Technique Necessary

Most investigators seem to have developed methods which were non-destructive of the mineral they sought and did not give due consideration to the presence of other minerals. Dr. Jones seeks such silicates as sericite, the hydrogen-potassium-aluminum silicate, and most of the earlier investigators sought only silica, and many of them ignored whether it was combined or free.

An improved method for destroying tissue without affecting foreign mineral particles is apparently needed. Because of coal dust or soot we should avoid oxidizing processes which will consume them, or the use of reactive development of acids which will affect our mineral matter. Are there any suitable organic solvents or could we employ parasitic life to consume the flesh and leave the mineral particles?

For all of these reasons it seems doubtful whether all former investigations of composition, weight, particulate counts, sizes, shapes, and size distribution of mineral particles from the lungs are of a value commensurate with the expenditure of time and money made. We must build a new technique and collect new data. The petrological examination, under revolving stage polarizing microscopes such as mineralogists use, with various condenser systems and sources of illumination, should be made on such particles from the lungs to observe their form, cleavage, color, mean refractive index, birefringence, and optic orientation. Specific gravity determinations are also desirable. It may be necessary to call into service the ultra-microscope.

Possibly, when former investigators learned the necessity of polarizing light to distinguish between different minerals they mounted polarizers upon biological microscopes with non-rotating stages and missed viewing the many particles which happened in an axial orientation on the slide which caused their optical extinction, and they quite likely misinterpreted some of the silicate minerals and thought them to be quartz. Their investigations therefore now have questionable value in respect to particle count and determination.

The optical determination of very small particles of quartz and silicates when imbedded in lung tissue has been unsatisfactory because of the difficulty of resolution of their images. Perhaps a new technique using much shorter wave lengths of light (say of 2,000 Angstrom units or shorter) can be developed to meet this need, because refractive indices will be increased thereby and smaller particles can also be optically resolved.

The relatively low birefringence of quartz does not permit its particles to show interference colors when between the crossed nicols (for polarized light) unless such particles are greater than three microns in thickness. As the average size of the dust particles in the lungs is less than three microns, it is evident that the only minerals which can be so determined are those with a higher double refraction than quartz; for example, calcite, rutile, zircon, sillimanite, sericite, and micas. Coal and carbon cannot be viewed by transmitted light.

Mineral Particles in Lungs

Too little, if any, emphasis has been placed upon the consideration that if the pathology of silicosis is produced by the toxic effects of silica that chemical must be absorbed in the system or undergo changes therein. So if it is dissolved or transformed, those particles remaining in the lungs are not the ones which have primarily done the damage. The less soluble particles would be those remaining after considerable time had elapsed subsequent to the removal of the exposure. Quartz is less soluble "in vitro" (in the chemical laboratory) than are silicates such as sericite. Is it possible that quartz is more soluble than the silicates in the supposedly weakly alkaline protoplasmic fluids? A great many sericite particles are found in the lung tissue, acording to Dr. Jones, in comparison with the number of phagocytozed quartz particles. Is it reasonable to surmise that quartz particles have gone into solution and produced toxic effects to a greater degree than the sericite, which may decompose and produce nascent toxic silica?

Shaft Concreting

Costs Vary Greatly

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Lining at Time of Sinking Cheaper

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M. J. Elsing
Consulting Engineer
Tucson, Arizona

CONCRETE has a wide variety of uses underground, the most important of which is the replacing of timber as shaft lining. In the form of gunite it plays an important rôle as a covering material. Applied to mine timber it acts as a preservative as well as making it practically fireproof. Gunite is also used instead of timber in certain classes of so-called slacking ground. In such applications it is probably more effective in sealing off the air and thus preventing slackening than in the actual support to the surface which it covers. Concrete has also proved an effective means of lining drifts, tunnels, and pump and shaft stations, and, when made thick and reinforced, has been the only effective means of keeping open such workings when the ground is really heavy. It also has such uses as bulkheads, fire doors, and foundations for pumps, motors, and other machinery.

Shafts are concreted generally for one or more of three reasons, namely: to free the shaft from the fire hazard present when timber is used; to make the shaft more permanent than it would be if lined with timber, and, lastly, to give greater support in heavy ground than timber affords.

One may safely state that shaft concreting has played an important part not only in reducing hoisting costs but also in adding safety and security to mine operating. Inasmuch as it is becoming more common, a review of the cost of doing such work should be of interest. By judicious selection of costs from published data one ought to be able to determine an approximate average cost for different types of shafts under ordinary conditions. The qualification "ordinary conditions" is perhaps somewhat indefinite. In this instance it refers to the type and character of the ground through which the shaft is driven.

Many factors determine the location of the shaft site, the most important being a rock formation which can be easily supported. Changes which cannot be predicted sometimes occur in formations, and often certain sections of a shaft may be in unfavorable ground. This is the case in two or three of the shafts to be discussed. The others are in good ground, the support of which was only a minor consideration when concreting was decided upon.

The shaft of the Morton mine, Hibbing, Minn., (*E. & M.J.* Sept. 25, 1909) is an illustration of the exceptional and unusual in shaft sinking and concreting. It was sunk through 190 ft. of water-bearing gravel and sand with several strata of clay and 2 ft. of cemented conglomerate. It is circular, 21 ft. in diameter, and was sunk by the drop-shaft method. A cutting edge was provided and material was excavated with a clam-shell bucket. As sinking progressed, additional rings of concrete were added to the top. At one time 1,000 tons of sand had to be put upon it to make it sink. The concrete walls are 4 ft. thick, reinforced with 1-in. square steel bars. The sinking rate was 6 to 7 in. per 10-hr. shift. This shaft was set on solid rock 190 ft. below surface. The work was done by contract at $500 per foot.

Data of the cost of concreting the shafts of several important Arizona copper mines are summarized in Tables I to V inclusive, on page 172.

No. 5 shaft of the United Verde Copper Company is 6 ft. 4 in. by 18 ft., outside of the concrete lining (*E.&M.J.* Feb. 20, 1926, I.C. 6440). It is divided in three compartments, each of which is 5x5 ft. All walls are 8 in. thick. Concreting was started from the bottom with 2-in. plank panels for forms. These were filled by passing concrete through a 5-in. pipe line from the mixing plant on the 500 level. With 21 men on three shifts 600 ft. of shaft was concreted in six months. Total cost of concrete was $22.50 per cubic yard.

No. 6 shaft of the same company extends from the 400 to the 3,000 level and is used for service only. It is 13x13 ft. inside of concrete walls 8 in. thick. It is divided by a 12-in. 40-lb. I-beam into a man and supply cage compartment, 8x13 ft. A 12-in. channel and an 8-in. I-beam provide three smaller compartments, one of which is a pipe and cable compartment, another a manway, and the third a counterweight compartment.

Above the 1,950 level, the shaft walls are solid concrete, but below, 2½-ft. concrete rings are placed at 6-ft. centers. The ring is made by pouring concrete into sectional steel forms supported by adjustable steel hangers from the ring above. Table V shows the comparative costs of concreting by both methods.

The cost of concreting per foot of shaft by the ring method was: labor, $16.60; shop, $5.90; supplies, $26.51; engineers, $1.05; miscellaneous, $0.05; total, $50.11. These costs do not include steel work, ladders, or pipe lines.

The Kingdon shaft of the Old Dominion Company, Globe, Ariz., after its destruction by fire, was concreted for 1,017 ft. The over-all dimensions were 12 ft. 4 in. by 8 ft. 6 in. An 8-in. dividing wall separated the shaft into two compartments, and the outside walls were 10 in. thick as a minimum. The contractors received $30,000 for the work, or approximately $29.50 per foot.

The Brier Hill shaft, Vulcan, Mich., was circular, 14 ft. in diameter, with walls 19 in. thick. The cost of concreting was approximately $41 per foot, or about $13.70 per cubic yard of concrete placed.

No. 3 shaft, Negaunee, Mich., was circular, with 17 ft. inside diameter and walls 18 in. thick. The cost of concreting was $39.50 per foot, or $12.34 per cubic yard of concrete placed.

A recapitulation of the most important cost data is given in Table VI. It should be borne in mind that these costs are not strictly comparable in every instance. In some cases some of the data given in this table have had to be calculated.

In estimating the cost of concreting a shaft, the thickness of the walls is one of the important considerations. If a minimum thickness of 10 in. is desired, liberal allowance should be made for excess breakage in the sectional area of the shaft. Few statistics relative to the average amount which should be allowed are available. In aqueduct tunnel work the excess yardage does not amount to more than 30 or 40 per cent and is sometimes as low as 15 to 20 per cent. Any estimate should include an excess of concrete over the theoretical amount or an allowance for back-filling and reinforcing that part of the wall in front of such filling.

Costs per foot of shaft as given in Column 2 of Table VI are exactly as reported in the original data. The cost per foot of shaft depends so much upon its size and the thickness of the walls that comparison of costs is difficult. Column 3 has therefore been included to show a cost per cubic yard of concrete used in the shaft. This is not the cost of the concrete alone, but the entire cost

of concreting divided by the number of yards of concrete used. Perhaps the fairest method of comparison is on the basis of the cubic contents of the shaft. This is figured with the dimensions outside of the concrete lining, and costs per cubic foot are shown in Column 4 of Table VI.

A few general conclusions can safely be drawn from the costs given in the foregoing. Naturally, costs vary considerably, but in most instances the cost of removing shaft timber and replacing it with a concrete lining has been somewhere between 20 and 40c. per cubic foot of shaft. For making rough estimates, perhaps 30c. per cubic foot would be a fair basis. If concrete lining is installed simultaneously with sinking, the outlay should be considerably less, because the cost of removing old timber and piping adds an appreciable amount. Cost of cement, sand, and gravel, and mixing and delivering it to the forms, on the average will be about $7 or $8 per cubic yard of concrete.

The benefits derived from concreting a mine shaft are not entirely calculable. Many costs in connection with shaft operation are reduced, but in addition there are those intangible benefits of absolute safety from the fire hazard which is ever present when timber is used.

Table I—Cost of Concreting Junction Shaft, Bisbee, Ariz., 1913

Footage	1,536
Yardage	8,374
Yards, per ft	5.5
Alterations in piping, per ft	$3.80
Alterations in transmission lines, per ft	1.05
Removing shaft timbers, per ft	7.44
Waste and filling, per ft	6.15
Guides, per ft	3.20
Hoisting, per ft	11.24
(*a*) Repairs to concrete pipe, per ft	0.06
(*a*) Repairs to concrete pipe, per yd. concrete	0.01
(*b*) Forms, per ft	3.07
(*b*) Forms, per yd. concrete	0.56
(*c*) Cost of concrete material, per ft	26.28
(*c*) Cost of concrete material, per yd. concrete	4.82
(*d*) Moving forms, per ft	10.12
(*d*) Moving forms, per yd. concrete	1.86
Distributing concrete, per ft	3.33
Distributing concrete, per yd. concrete	0.61
Concrete, total of (*a*) (*b*) (*c*) (*d*), per ft	39.53
Concrete, total of (*a*) (*b*) (*c*) (*d*), per yd. concrete	7.25
Supervision, per ft	2.34
Supervision, per yd. concrete	0.43
Miscellaneous, per ft	0.92
Miscellaneous, per yd. concrete	0.17
Total, per ft. of shaft	$79.00
Total, per cu.yd. of concrete	$14.36
Total, per cu.ft. of shaft	0.27

(*a*) Includes cost of new hoist rope.
(*b*) Shift bosses in December and January were charged to supervision.
(*c*) Concrete cost includes cost of quarrying and crushing rock, freight, sand, cement and supplies, mixing and storing concrete, and the cost of reinforcement.

Notes:
Reference, *E.&M.J.*, May 16, 1914.
Company, Calumet & Arizona Mining Company.
Author, R. H. Dickson.
Time, 8 months 24 days.
Outside dimension, 31x9.4 ft.
Number compartments, 5.
Mix, 1:3:5.

Table II—Cost of Concreting Denn Shaft, Bisbee, Ariz., 1932

Footage		2,230
Yardage		9,934
Yards per ft		4.47
	Per Ft.	Per Ft.
Mixing plant	$0.71	
Material-handling plant	.96	
Concrete forms	4.86	
Concrete pouring 4-in. pipe	.84	
Preparatory work	$7.37	$7.37
Direct labor		$20.70
Direct material		
Cement, 10,934 bbl.	15.05	
Sand, 5,991 tons	2.76	
Rock, 9,052 tons	5.32	
Celite, 55,750 lb.	.36	
Steel	.81	
Timber	1.12	
Miscellaneous	.23	
Total	$25.65	$25.65
Engineering and surface supervision		2.02
Hoisting		8.63
Testing materials		.92
Water and light		1.51
Maintenance mixing plant		.59
Handling supplies		5.08
Shaft guide pockets		1.79
Miscellaneous		5.99
Concreting cost		$72.88
Total cost including preparatory work		$80.25
Cost per cu.yd. of concrete		17.82
Cost per cu.ft. of shaft		.38
Credit of $30,000 maintenance per foot		13.45
Net cost of shaft per foot		66.80

Notes:
Reference, *E.&M.J.* Dec., 1932.
Company, Shattuck-Denn Mining Corporation.
Author, F. P. Brunel.
Time, 9 months, 14 days.
Outside dimension, 1,350 ft., 21x9.4 ft.; 880 ft., 24x9.4 ft.
Number compartments, 1,350 ft., 3; 880 ft., 4
Mix, 1:3:5

Table III—Cost of Concreting Sacramento Shaft, Bisbee, Ariz., 1915

Footage, 1,640 ..... Yardage, 6,270 ..... Yards per ft., 3.8

	Per Foot
Miscellaneous preparatory expense	$0.73
Aligning guides	.34
Routine labor in shaft	11.15
Concrete	26.01
Concrete dividers	2.23
Miscellaneous supplies	5.68
New guides and ladders	1.34
Hoisting engineers	1.13
Supervision	2.05
Accident compensation	.05
Total	$50.71
Credit for timber delivered to mine department	1.70
Net cost per foot	$49.01
Cost per Yard of Concrete in Place	
Sand and rock	$1.69
Cement	3.44
Total	$5.13
Mixing	.56
Concrete column, elbows, air lines	.39
Forms	.75
Cost per yard of concrete at forms	$6.83

Notes:
Reference, *M.&S.P.* Oct. 7, 1916.
Company, Copper Queen Consolidated Mining Company.
Author, Gerald Sherman.
Time, 9 months, 13 days. (Hoisting permitted 14 hr. per day.)
Outside dimensions, 29x8 ft.
Number compartments, 5. Mix, 1:3:5.

Table IV—Cost of Concreting U.V.X. Shaft, Jerome, Ariz., 1921

Footage, 1,205 ..... Yardage, 2,420 ..... Yards per ft., 2.0

	Cost per Foot Under Contract, 575 Ft.	Bonus, 630 Ft.
Labor	$15.35	$8.05
Cement, $1.10 per sack	12.56	10.92
Sand and gravel, $2.50 per yd	6.51	5.69
Power, 2c per kw.-hr	.88	.93
Reinforcing, 10c per lb	1.00	1.00
Form lumber	1.50	1.50
Bonus paid	5.34	3.26
Total per foot	$43.15	$31.35
Average for both sections	$37.00	
Average cost per yd. concrete	18.50	
Average cost per cu.ft. of shaft	.30	

Notes:
Reference, Information Circular 6250, U. S. Bureau of Mines.
Company, United Verde Extension Mining Company. Author, R. L. D'Arcy.
Time, 5 months, 25 days.
Outside dimensions, 16.5x7.5 ft.
Number of compartments, 3. Mix, 1:2:5.

Table V—Comparative Cost Solid Concrete and Rings, United Verde, Jerome, Ariz.

Method	Concrete Mix	Feet	Concrete Cost Per Ft. of Shaft	Concrete Cost Per Cu.Yd. Concrete
Solid	1:3:5	1,550	$146.84	$61.30
Ring	1:2:4	1,050	50.11	58.80

Table VI—Summary of Cost of Shaft Concreting

Column	1	2	3	4	5	6
Shaft	Cu.Yd. Concrete per Ft. of Shaft	Cost of Concreting per Ft. of Shaft	Cost of Concreting per Cu.Yd. Concrete	Cost of Concreting per Cu.Ft. of Shaft	Outside Area Shaft, Sq.Ft.	Thickness Outside Walls, Ft.
Junction	5.5	$79.00	$14.36	$0.27	288	1.7
Denn	4.5	80.25	17.82	.38	210	1.7
Copper Queen	3.8	49.01	12.90	.21	237	1.3
United Verde Extension	2.0	37.00	18.50	.30	124	1.0
United Verde (*a*)	2.4	146.84	61.30	.72	205	.7
United Verde (*b*)	.8	59.11	58.80	.24	205	...
Kingdon	1.6	29.50	18.44	.28	105	.8
Brier Hill	3.0	41.00	13.70	.19	216	1.6
Negaunee	3.2	39.50	12.34	.13	314	1.5
Dawson	3.4	30.79	9.09	.20	150	1.4

(*a*) Solid concrete. (*b*) Ring method

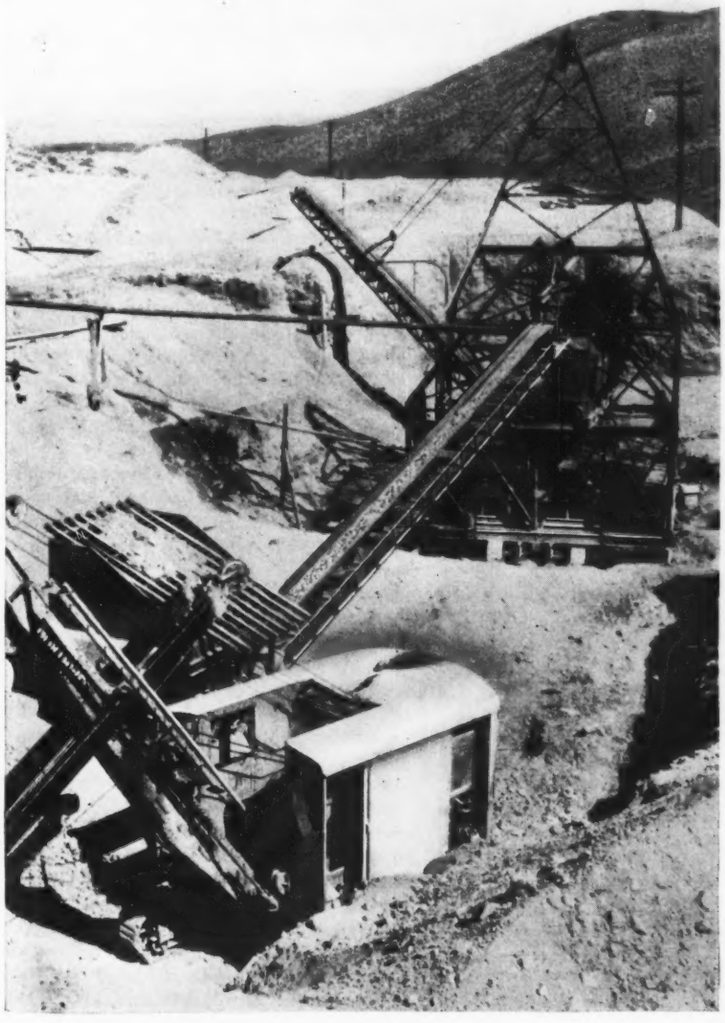
Portable Washing Plant

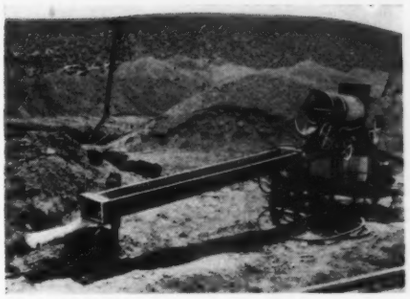
Economical in Power and Equipped Like A Pontoon Dredge

John B. Huttl
Assistant Editor

ONE of the most interesting gold placer operations employing successfully a portable gravel treatment plant is that of the Apex Mining Company at Yerington, Nev. The residual gravel mined and treated is angular rather than round. About half of that mined is screen oversize. Values contained average 60c. per cubic yard based on the present price of gold. The caterpillar-mounted plant, known as the Massco "dry land dredge" treatment plant, is particularly noteworthy in respect to power consumption, and because it uses equipment like that of the pontoon-type dredge (which consists of a steel hull, or pontoon, carrying a digging ladder trommel, tables, sluices, and a stacker). Capacity is 75 cu.yd. per hour consuming 50 hp. Water consumption is about 1,500 g.p.m. Exploitation of proved placer ground is relatively simple.

Placer mining at Yerington, Nev., with a "dry land dredge" and portable treating plant





Portable placer machine used for test purposes

The bank-run gravel is excavated by a Northwestern power shovel, the dipper discharging to an 8-ft. loading hopper through an 8-in. rail grizzly having 8-in. spacing. Oversize is dumped beside the hopper. Undersize is delivered by a 24x60-in. plate feeder, eccentric-driven from the feed-conveyor tail shaft, to a 24-in. 50-ft. feed conveyor carried on structural steel supports and supplied with an auxiliary A-frame. This conveyor is at the discharge end so that it may be swung 75 deg. horizontally on either side of the center line of the portable treatment plant.

Equipped With Trommel and Tables

The undersize goes to a 5x21-ft. rotary trommel having a feed hopper and a discharge chute. A screen with ½-in. round holes covers 12 ft. of the trommel, one with ½x1-in. rectangular perforations the next 2 ft., and a scrubber section for disintegrating clayey or cemented material, and for washing the gravel prior to screening, constitutes the rest. The oversize discharge chute contains riffles to trap nuggets.

The screen oversize goes to a 75-ft. 24-in. stacker conveyor so mounted that it can be swung through a 150 deg. horizontal arc. Screen undersize is distributed over two sets of eight gold-saving tables, or parallel sluices, each measuring 2x8 ft. and having Hungarian riffles on a rubber-lined bottom. Table discharge passes through two 2x21-ft. sluices, riffled like the transverse tables and running lengthwise along each side of the plant. A convenient lever makes it possible to raise the Hungarian riffles and clean out each sluice.

Sluice tailings go to two sand drags and then to the stacker feed hopper. The Model 12-S GB portable placer machine shown in one of the cuts is used for test purposes.

Average Cost of Producing Copper, 1922-1932

Prepared by the Minerals Division, U. S. Bureau of Foreign and Domestic Commerce

(Sources: Production data, American Bureau of Metal Statistics and U. S. Bureau of Mines; financial data, Moody's Investors Service and the Mines Handbook, by Rand and Sturgis)

I—Based on Total Dividends

Mining Companies —U. S.:	Production 000 Pounds	Total Dividends— Total Dollars	Total Dividends— Average per Pound Cents	Average Selling Price per Pound Cents (1)	Average Cost per Pound Cents	Ratio Copper Sales to Total Sales per Cent
Anaconda Copper	2,186,072	95,227,607	4.356	13.448	9.092	59.3
Calumet & Arizona (2)	524,913	29,473,646	5.615	14.711	9.096	85.6
Calumet & Hecla (3)	854,742	29,079,778	3.402	13.521	10.119	100.0
Champion Copper (4)	169,997	6,320,003	3.718	14.185	10.467	100.0
Copper Range	89,304	4,045,513	4.530	11.528	6.998	100.0
Inspiration Consolidated	840,991	14,185,604	1.687	12.990	11.303	100.0
Isle Royal Copper	95,875	1,462,500	1.525	13.673	12.148	100.0
Magma Copper	274,061	8,928,313	3.258	13.650	10.392	86.3
Miami Copper	594,408	12,887,736	2.168	13.375	11.207	100.0
Mohawk	172,020	5,527,388	3.213	13.356	10.143	100.0
Mother Lode Coalition	215,016	14,000,000	6.511	13.567	7.056	96.6
Nevada Consolidated (5)	1,994,264	47,035,766	2.359	13.687	11.328	97.3
New Cornelia (6)	431,367	16,380,000	3.797	13.743	9.946	96.4
Old Dominion (7)	210,685	Def —3,504,749	Def. —1.664	13.644	15.308	94.7
Phelps Dodge	1,879,513	31,478,000	1.675	13.228	11.553	56.4
Utah Copper	2,100,147	112,901,654	5.350	13.713	8.363	93.4
United Verde (8)	903,552	38,400,000	4.250	14.285	10.035	86.9
United Verde Extension	460,696	24,816,560	5.387	13.347	7.960	93.6
Total mining companies	14,007,623	488,645,319	3.488	13.578	10.090	....
Total U. S. mine production	15,836,749	.....	.....	.....	.....	....
Per cent of total	88.5	.....	.....	.....	.....	....
Smelting and Refining Companies:						
American Metal	3,921,094	20,460,758	0.522	13.283	12.761	49.4
American Smelting & Refining	9,514,684	81,448,195	0.856	13.684	12.828	46.0
Total smelting and refining	13,435,778	101,908,953	0.758	13.567	12.809	
Total U. S. smelter production	16,913,451	.....	.....	.....	.....	....
Per cent of U. S. total	79.4	.....	.....	.....	.....	....
Foreign Mining Companies:						
Andes Copper (9)	522,092	10,828,498	2.074	14.139	12.065	98.0
Cerro de Pasco	903,666	42,614,301	4.716	13.240	8.524	54.5
Chile Copper	2,207,995	106,176,596	4.809	13.559	8.750	100.0
Granby Consolidated	490,416	8,015,584	1.634	13.149	11.515	93.7
Greene Cananea	388,909	7,125.000	1.832	13.102	11.270	92.3
Hudson Bay (10)	75,599	Def.— 597,896	Def.—0.791	6.841	7.632	45.0
Kennecott (Braden and Alaska)	2,140,593	93,007,870	4.345	13.119	8.774	99.3
Noranda Mines, Ltd. (11)	285,669	8,111,901	2.840	11.376	8.536	65.5
Katanga	2,092,936	40,308,792	1.926	12.132 (12)	10.206	100.0
Total foreign companies	9,107,875	315,592,546	3.465	12.963	9.498	....
Total U. S. and foreign	23,115,498	.....	.....	.....	.....	....
Total world mine production	34,845,907	.....	.....	.....	.....	....
Per cent of world mine production	66.3	.....	.....	.....	.....	....

Notes: (1) Average selling price for each company is weighted according to company yearly output, based on average New York selling price for the year; also the average for all companies combined is weighted accordingly. (2) Calumet & Arizona—1922 to 1930, inclusive. (3) Calumet & Hecla—1923 to 1932, inclusive. (4) Champion Copper—1922 to 1930 inclusive. (5) Nevada Consolidated—includes Ray and Chino Mines prior to 1926. (6) New Cornelia—1922 to 1928, inclusive. (7) Old Dominion—1922 to 1931, inclusive. (8) United Verde Copper — 1922 to 1931, inclusive. (9) Andes Copper—1927 to 1932, inclusive. (10) Hudson Bay—1930 to 1932, inclusive. (11) Noranda—1928 to 1932, inclusive. (12) London price.

II—Based on Total Dividends Plus Interest on Bonded Indebtedness

Mining Companies —U. S.:	Production 000 Pounds	Total Dividends Plus Interest on Bonded Debt Total Dollars	Total Dividends Plus Interest on Bonded Debt Average per Pound Cents	Average Selling Price per Pound Cents(1)	Average Cost per Pound Cents	Ratio Copper Sales to Total Sales per Cent,
Anaconda Copper	2,186,072	158,966,477	7.272	13.448	6.176	59.3
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Calumet & Hecla (3)	854,742	29,079,778	3.402	13.521	10.119	100.0
Champion Copper (4)	169,997	6,320,003	3.718	14.185	10.467	100.0
Copper Range (4)	89,304	5,178,834	5.799	11.528	5.729	100.0
Inspiration Consolidated	840,991	16,511,524	1.963	12.990	11.037	100.0
Isle Royal Copper	95,875	1,462,500	1.525	13.673	12.148	100.0
Magma Copper	274,061	9,673,851	3.530	13.650	10.120	86.3
Miami Copper	594,408	12,887,736	2.168	13.375	11.207	100.0
Mohawk	172,020	5,527,388	3.213	13.356	10.145	100.0
Mother Lode Coalition	215,016	14,000,000	6.511	13.567	7.056	96.6
Nevada Consolidated (5)	1,994,264	48,364,047	2.425	13.687	11.262	97.3
New Cornelia (6)	431,367	16,380,000	3.797	13.743	9.946	96.4
Old Dominion (7)	210,685	Def.—3,504,749	Def.—1.664	13.644	15.308	94.7
Phelps Dodge	1,879,513	31,478,000	1.675	13.228	11.553	56.4
Utah Copper	2,110,147	112,901,654	5.350	13.713	8.363	93.4
United Verde (8)	903,552	38,400,000	4.250	14.285	10.035	86.9
United Verde Extension	460,696	24,816,560	5.387	13.347	7.960	93.6
Total mining companies	14,007,623	557,917,249	3.983	13.578	9.595	....
Total U. S. mines production	15,836,749	.....	.....	.....	.....	....
Per cent of total	88.5	.....	.....	.....	.....	....

. . COSTS . . AND THE

An Interpretation

H. D. Keiser

Associate Editor

RECENT DISCUSSIONS on codes of fair competition for various branches of the metal-mining industry have throughout their course revealed the importance of production costs as a basic factor in reaching agreements for the achievement of code objectives. Early recognition of this fact on the part of a government agency—the Minerals Division of the U. S. Bureau of Foreign and Domestic Commerce—prompted the preparation of a statistical cost analysis of the principal non-ferrous metal-mining industries, the entire analysis being based on readily accessible published information. The major part of this study, consisting of a number of tables, *Engineering and Mining Journal* is privileged to present here and in several subsequent articles.

During the last 50 years the non-ferrous metal industries, especially copper, lead, and zinc, have been subject to alternating periods of prosperity and extreme depression. These violent fluctuations caused uneven employment of labor and social disturbances. Development of a basis on which to determine the number of men remuneratively employed would therefore seem necessary in making a study of past performance of these industries if an indication is to be obtained of what may be expected of them in the immediate future. In reaching such a basis, the first step is to show how successful from a monetary standpoint an industry has been in the past, and then to determine the number of employees involved, thereby establishing a ratio of earnings by the industry to the number of men employed. Clearly, in this procedure, the ordinary method of determining costs is not employed. The procedure is not based on any unusual form of bookkeeping or arbitrary valuation of property, such as depreciation and depletion, but rather on what industry has distributed as profit and what relationship that profit has to the sales price of the commodity produced. The fundamental difference between the procedure and the usual methods employed is that, in the former, dividends or profits are credited to the unit of production of the metal and not to a share of the company's stock.

..CODES.. FUTURE of Significant Data

The study made in preparing the accompanying tables was based upon the thought that by taking the period of eleven years, 1922-1932, a complete business cycle was represented. The low price prevailing for metals during 1922, the high price of 1929, and the low price of 1932, represent the valleys and peak of remunerative rates for capital investment. What happened in this period should provide certain basic data that may be used to advantage in planning for the future welfare of the mining industries. The contention may, perhaps, be made that the period 1922-1932 is too short to cover all the vicissitudes of these industries; but during the period selected a greater advance was made in technology than in any corresponding period throughout the history of these metals, and to detract from these benefits by taking a longer period of time would tend to distort the facts as presented.

The study was predicated upon the idea that employment of labor cannot take place without remuneration to those investing in the project. So, believing that the subject could be approached only from the standpoint of dividends paid, the tables were prepared in the form shown. Three methods of presenting the cost data were employed: First, costs based solely on dividends. This method shows what has been paid to the investors in the companies enumerated. A stockholder is a partner in the enterprise, and dividends show the reason why, from a remunerative standpoint, he remains a stockholder. The second method is based upon dividends plus bonded indebtedness. This method brings out two points: First, bonded indebtedness is paid from earnings, and the competitive position of one company with another is indicated by their actual earnings as applied on dividends and bonded indebtedness. Second, individuals receiving interest on bonds are not partners in the company but merely creditors. The third method, based upon earnings, of a necessity takes into consideration surpluses earned during the year which may be applied later to reduction of capital investment or to *ad interim* dividends or may never reach the investor in any remunerative form.

In the tables, total dividends paid, irrespective of their source, have been

Average Cost of Producing Copper, 1922-1932—Continued

Smelting and Refining Companies:						
American Metal	3,921,094	23,546,092	0.600	13.283	12.683	49.4
American Smelting & Refining	9,514,684	105,327,152	1.107	13.684	12.577	46.0
Total smelting and refining	13,435,778	128,873,244	0.959	13.567	12.608	....
Total U. S. smelter production	16,913,451	.....	.....	.....	.....	....
Per cent of U. S. total	79.4	.....	.....	.....	.....	....
Foreign Mining Companies:						
Andes Copper (9)	522,092	16,413,098	3.144	14.139	10.995	98.0
Cerro de Pasco	903,666	43,631,661	4.828	13.240	8.412	54.5
Chile Copper	2,207,995	131,716,396	5.965	13.559	7.594	100.0
Granby Consolidated, Ltd.	490,416	9,526,726	1.942	13.149	11.207	93.7
Greene Cananea	388,909	7,125,000	1.832	13.102	11.270	92.3
Hudson Bay (10)	75,599	676,221	0.894	6.841	5.947	45.0
Kennecott (Braden and Alaska)	2,140,593	93,007,870	4.345	13.119	8.774	99.3
Noranda Mines, Ltd. (11)	285,669	8,111,901	2.840	11.376	8.536	65.0
Katanga	2,092,936	40,308,792	1.926	12.132(12)	10.206	100.0
Total foreign companies	9,107,875	350,517,665	3.849	12.963	9.114	....
Total U. S. and foreign	23,115,498	.....	.....	.....	.....	....
Total world production	34,845,907	.....	.....	.....	.....	....
Per cent of world production	66.3	.....	.....	.....	.....	....

Notes: (1) Average selling price for each company is weighted according to company yearly output based on average New York selling price for the year; also the average for all companies combined is weighted accordingly. (2) Calumet & Arizona—1922 to 1930, inclusive. (3) Calumet & Hecla—1923 to 1932, inclusive. (4) The Copper Range Company up until 1931 owned a half interest in the Champion Copper Company, at which time it took over the latter in entirety. In the annual statements of the Copper Range, 50 per cent of the Champion production is shown each year and to obtain the actual production of Copper Range from 1922 to 1930, inclusive, this 50 per cent of Champion production was deducted, as Champion is shown separately from 1922 to 1930, inclusive, after which latter year it is consolidated with the Copper Range. (5) Nevada Consolidated—includes Ray and Chino Mines prior to 1926. (6) New Cornelia—1922 to 1928, inclusive. (7) Old Dominion—1922 to 1931, inclusive. (8) United Verde Copper—1922 to 1931, inclusive. (9) Andes Copper—1927 to 1932, inclusive. (10) Hudson Bay—1930 to 1932, inclusive. (11) Noranda—1928 to 1932, inclusive. (12) London price.

III—Based on Net Earnings

	Production 000 Pounds	Net Earnings: Total Dollars (14)	Net Earnings: Average per Pound Cents	Average Selling Price per Pound Cents (1)	Average Cost per Pound Cents	Ratio of Copper Sales to Total Sales per Cent
Mining Companies —U. S.:						
Anaconda Copper	2,186,072	105,195,515	4.812	13.448	8.636	59.3
Calumet & Arizona (2)	524,913	24,840,791	4.732	14.711	9.979	85.6
Calumet & Hecla (3)	854,742	1,730,426	0.202	13.521	13.319	100.0
Champion Copper (4)	169,997	1,231,375	0.724	14.185	13.461	100.0
Copper Range	89,304	Def.—1,826,258	Def.—2.045	11.528	13.573	100.0
Inspiration Consolidated	840,991	14,095,448	1.676	12.990	11.314	100.0
Isle Royal Copper	95,875	Def.—1,721,824	Def.—1.796	13.673	15.469	100.0
Magma Copper	274,061	7,947,117	2.900	13.650	10.750	86.3
Miami. Copper	594,408	6,682,632	1.124	13.375	12.251	100.0
Mohawk	172,020	4,146,077	2.410	13.356	9.946	100.0
Mother Lode Coalition	215,016	4,305,527	2.002	13.567	11.565	96.6
Nevada Consolidated (5)	1,994,264	56,249,047	2.821	13.687	10.866	97.3
New Cornelia (6)	431,367	13,580,320	3.148	13.743	10.595	96.4
Old Dominion (7)	210,685	Def.—3,504,749	Def.—1.664	13.644	15.308	94.7
Phelps Dodge	1,879,513	Def.—24,548,941	Def.—1.306	13.228	14.534	56.4
Utah Copper	2,110,147	121,637,313	5.764	13.713	7.949	93.4
United Verde (8)	.....	.....	.....	.....	.....	.....
United Verde Extension	460,696	Def.—(9) 41,788	Def.—(9) 0.009	13.347	13.356	93.6
Total mining companies	13,104,071	329,998,028	2.518	13.530	11.012	....
Total U. S. mine production	15,836,749	.....	.....	.....	.....	....
Per cent of total	82.7	.....	.....	.....	.....	....
Smelting and Refining Companies:						
American Metal	3,921,094	23,386,910	0.596	13.283	12.687	49.4
American Smelting & Refining	9,514,684	122,344,304	1.286	13.684	12.398	46.0
Total smelting and refining	13,435,778	145,731,214	1.085	13.567	12.482	....
Total U. S. smelter production	16,913,451	.....	.....	.....	.....	....
Per cent of U. S. total	79.4	.....	.....	.....	.....	....
Foreign Mining Companies:						
Andes Copper (10)	522,092	18,903,764	3.621	14.139	10.518	98.0
Cerro de Pasco	903,666	20,791,491	2.301	13.240	10.939	54.5
Chile Copper	2,207,995	102,216,396	4.629	13.559	8.930	100.0
Granby Consolidated	490,416	Def.—3,830,125	Def.—0.781	13.149	13.930	93.7
Greene Cananea	388,909	6,628,818	1.704	13.102	11.398	92.3
Hudson Bay (11)	75,599	Def.— 597,896	Def.—0.791	6.841	7.632	45.0
Kennecott (Braden and Alaska)	2,140,593	97,784,364	4.568	13.119	8.551	99.3
Noranda Mines, Ltd. (12)	285,669	15,464,395	5.413	11.376	5.963	65.5
Katanga	2,092,936	36,522,175	1.745	12.132 (13)	10.387	100.0
Total foreign companies	9,107,875	293,883,382	3.227	12.963	9.736	....
Total U. S. and foreign	22,211,946	.....	.....	.....	.....	....
Total world mine production	34,845,907	.....	.....	.....	.....	....
Per cent of world mine production	63.7	.....	....	.....	.....	....

Notes: (1) Average selling price for each company is weighted according to company yearly output, based on average New York selling price for the year; also the average for all companies combined is weighted accordingly. (2) Calumet & Arizona—1922 to 1930, inclusive. (3) Calumet & Hecla—1923 to 1932, inclusive. (4) Champion Copper Company—1922 to 1930, inclusive. (5) Nevada Consolidated—includes Ray and Chino Mines prior to 1926. (6) New Cornelia—1922 to 1928, inclusive. (7) Old Dominion—1922 to 1931, inclusive. (8) No data available. (9) Not actual deficit, but is due to high rate charged for depletion. (10) Andes Copper —1927 to 1932, inclusive. (11) Hudson Bay—1930 to 1932, inclusive. (12) Noranda—1928 to 1932, inclusive. (13) London price. (14) Take into account in most instances depreciation and depletion.

used, and the total production in pounds of the respective metals by the various companies enumerated has been employed to show the average dividend in cents per pound of the metal produced. This method may invite some criticism, but, if the competitive position of one company with another is being considered, whether dividends are derived from direct production of metal, or from, let us say, government bonds is of little importance. However, in the instance of some of the larger companies with a wide range of activities, this results in a somewhat different or out-of-focus "average cost per pound" picture, but nevertheless this cost figure illustrates the relative competitive position of the companies having diversified interests with reference to other companies and their influence on the metal markets. Final comparisons regarding the competitive position of the various companies cannot be made until the "total investment per pound of actual output" for the various companies is considered; which study will be presented in a subsequent article in the series.

Average selling price is the weighted price for each company, according to the company's yearly output and average metal prices published in *Engineering and Mining Journal*. Average cost is the difference between the average selling price per pound and average dividends. The ratio "sales to total" is the ratio of sales of the respective metals to sales of all products.

Here, note may well be made that if any undisclosed surpluses are acquired over a period of years by a company, such surpluses are used either to equalize dividends over a number of years, or to acquire new property, or to expand production, or to reduce costs. Eventually the surplus will appear as dividends, if additional investments were wise; if they were not, the surplus is wasted and it becomes an item of cost. Consequently, over a period of years, any differences between reported annual earnings and those shown in the tables are cancelled by compensating errors.

As to the future: NRA pronouncements seem more and more to indicate that certain principles of the New Deal are here to stay. Among these apparently is planning for industry from the standpoint of national welfare. Any program of long-time planning for the mining industries would probably involve consideration of the following factors: maintenance of statistical services; appraisals of consumptive requirements; determination of selling prices, wages, and cost; capacity, reserve, depletion; relation of mechanization to employment and costs; Federal and State control of minerals; exchange of minerals among nations; taxes, tariffs, marketing, cartels; conservation; domestic and foreign mining laws. Such a program, in view of the wide variation in status of the different members of any one of the principal non-ferrous metal industries, as revealed by the accompanying tables, would seem a stupendous task. And for the same basic reason, perhaps, has codification of these industries been so long delayed.

In conclusion, acknowledgment is made to J. R. Finlay, consulting mining engineer and authority on mining costs, for developing the method of determining costs that was employed in the foregoing study, by which method costs are measured by the difference between gross income received for the product and the amounts distributed as bond interest and dividends.

Average Cost of Producing Lead, 1922-1932

Prepared by the Minerals Division, U. S. Bureau of Foreign and Domestic Commerce.
(Sources: Production data, American Bureau of Metal Statistics; financial data, Moody's Investors Service, and the Mines Handbook, by Rand and Sturgis)

I—Based on Total Dividends

Companies:	Total Production, Pounds	Total Dividends, Dollars	Average Dividends per Pound, Cents	Average (4) Selling Price per Pound, Cents	Average Cost per Pound, Cents
Bingham Mines (1)	93,040,000	717,375	0.771	7.363	6.592
Bunker Hill & Sullivan	908,220,000	22,331,875	2.460	6.439	3.979
Callahan Zinc-Lead	23,040,000	Def.—892,514	Def.—3.874	6.825	10.699
Dayrock Mining (2)	25,404,000	253,965	1.000	6.520	5.520
Hecla Mining	542,578,000	11,200,000	2.064	6.575	4.511
North Lily (3)	77,050,000	1,073,992	1.394	6.258	4.864
Park Utah Consolidated	310,934,000	7,875,682	2.533	7.084	4.551
St. Joseph Lead	3,203,684,000	52,093,569	1.626	6.637	5.011
Silver King Coalition	364,492,000	9,743,686	2.673	6.696	4.023
Tintic Standard	404,378,000	12,734,375	3.149	6.942	3.793
Utah Apex	232,780,000	2,244,850	0.964	7.358	6.394
U. S. Smelting, Refining & Mining	1,127,050,000	27,649,361	2.453	6.715	4.262
Totals	7,312,650,000	147,026,216	2.011	6.687	4.676
Total U. S. Production	14,267,558,000				
Per cent of U. S. Production	51.25				

Notes: (1) 1922 to 1928, inclusive. (2) 1923 to 1930, inclusive. (3) 1928 to 1932, inclusive. (4) New York selling price—average selling price for each company is weighted according to company yearly production, based on average price for each year; also the average of all the companies is weighted according to total production of each company.

II—Based on Total Dividends Plus Interest on Bonded Indebtedness

Mining Companies:	Total Production, Pounds	Total Dividends and Bond Interest, Dollars	Average Dividend and Bond Interest per Pound, Cents	Average Selling Price(1) per Pound, Cents	Average Cost per Pound, Cents	Ratio of Lead Sales to Total Sales, per Cent
Bingham Mines (2)	93,040,000	717,375	0.771	7.363	6.592	50.6
Bunker Hill & Sullivan	908,220,000	22,331,875	2.460	6.439	3.979	84.2
Butte & Superior (3)	65,866,000	3,337,271	5.067	7.370	2.303	8.4
Callahan Zinc-Lead	23,040,000	Def.—892,514	Def.—3.874	6.825	10.699	42.4
Chief Consolidated	178,218,000	2,136,410	1.198	7.339	6.141	40.9
Dayrock Mining (4)	25,404,000	253,965	1.000	6.520	5.520	79.7
Hecla Mining	542,578,000	11,200,000	2.064	6.575	4.511	80.8
North Lily Mining (5)	77,050,000	1,073,992	1.394	6.258	4.864	69.4
Park Utah Consolidated	310,934,000	7,875,682	2.533	7.084	4.551	34.0
St. Joseph Lead	3,203,684,000	53,254,069	1.662	6.637	4.975	90.0
Silver King Coalition	364,492,000	9,743,686	2.673	6.696	4.023	55.5
Tintic Standard	404,378,000	12,734,375	3.149	6.942	3.793	53.9
Utah Apex Mining	232,780,000	2,244,850	0.964	7.358	6.394	52.9
Total mining companies	6,429,684,000	126,011,036	2.065	7.068	5.003	....
Total U. S. mine production	12,367,514,000					
Percentage of total	52					
Smelting Companies:						
American Metal	2,410,212,000	23,546,092	0.977	6.697	5.720	15.3
American Smelting & Refining	9,048,398,000	105,327,152	1.164	6.693	5.529	21.5
Federal Mining, Smelting & Refining	809,322,000	8,601,227	1.063	6.856	5.793	49.9
U. S. Smelting & Refining	1,127,050,000	32,203,821	2.857	6.715	3.858	24.3
Total smelting companies	13,394,982,000	169,678,292	1.267	6.706	5.439	....
Total U. S. refined lead production	14,267,558,000					

Notes: (1) Average selling price for each company is weighted according to company yearly output, based on average New York price for year; also the average for all companies combined is weighted accordingly. (2) Bingham Mines Company, 1922 to 1928, inclusive; (3) Butte & Superior, 1922 to 1930, inclusive; (4) Dayrock Mining, 1923 to 1930, inclusive; (5) North Lily, 1928 to 1932, inclusive.

III—Based on Net Earnings

Companies:	Total Production, Pounds	Total Net(5) Earnings, Dollars	Average Earnings per Pound, Cents	Average (3) Selling Price per Pound, Cents	Average Cost per Pound, Cents
Bingham Mines (1)	93,040,000	1,116,096	1.200	7.363	6.163
Bunker Hill & Sullivan	908,220,000	25,621,822	2.821	6.439	3.618
Callahan Zinc-Lead (4)	23,040,000	Def.-892,514	Def.-3.874	6.825	10.699
Hecla Mining	542,578,000	15,218,865	2.805	6.575	3.770
North Lily (2)	77,050,000	1,836,812	2.384	6.258	3.874
Park Utah Consolidated	310,934,000	6,991,659	2.249	7.084	4.834
St. Joseph Lead	3,203,684,000	47,347,979	1.478	6.637	5.159
Silver King Coalition	364,492,000	12,285,823	3.371	6.696	3.325
Tintic Standard	404,378,000	15,644,518	3.869	6.942	3.073
Utah Apex	232,780,000	1,316,744	0.566	7.358	6.792
U. S. Smelting & Refining	1,127,050,000	38,378,408	3.405	6.715	3.310
Totals	7,287,246,000	163,866,212	2.249	6.688	4.439
Total U. S. Production	14,267,558,000				
Per cent of U. S. Production	51.08				

Notes: (1) 1922 to 1928, inclusive. (2) 1928 to 1932, inclusive. (3) New York selling price — average selling price for each company is weighted according to company yearly production, based on average price for each year; also the average of all companies for the entire period is weighted according to total production of each company. (4) No production for years 1924, 1925, 1931, and 1932, although company deficits are taken into consideration for those years. (5) Take into account in most instances depreciation and depletion.

Average Cost of Producing Zinc, 1922-1932

Prepared by the Minerals Division, U. S. Bureau of Foreign and Domestic Commerce.
(Sources: Production data, American Bureau of Metal Statistics; financial data, Moody's Investors Service, and the Mines Handbook, by Rand and Sturgis)

I—Based on Total Dividends

Companies:	Total Production, Pounds	Total Dividends, Dollars	Average Dividends per Pound, Cents	Average (6) Selling Price per Pound, Cents	Average Cost per Pound, Cents
American Metal	1,065,096,000	20,460,758	1.921	6.243	4.322
American Smelting & Refining	995,928,000	81,448,195	8.178	5.700	.....
Bunker Hill & Sullivan (1)	45,740,000	8,737,577	19.103	4.450	.....
Butte & Superior (2)	567,336,000	3,337,271	0.588	6.430	5.842
Federal Mining & Smelting	709,652,000	8,601,227	1.212	6.463	5.251
New Jersey Zinc (5)	1,197,420,000	38,116,714	3.183	6.555	.....
Park Utah Consolidated (3)	269,589,000	7,345,937	2.725	6.289	3.564
St. Joseph Lead (4)	446,260,000	46,048,607	10.319	5.287	.....
Silver King Coalition (4)	79,239,000	9,743,686	12.296	5.462	.....
U. S. Smelting & Refining	491,624,000	27,649,361	5.624	5.789	0.125
Utah Apex	98,126,000	2,244,850	2.288	6.616	4.328
Totals	5,966,010,000	253,734,183	4.252	6.163	1.911

Per cent of total U. S. production for 1922–32... 55.3
Total U. S. production (1922–1932, inclusive) primary zinc metal..... 10,782,302,000

Notes: (1) For years 1928 to 1932, inclusive. (2) For years 1922 to 1930, inclusive. (3) For years 1923 to 1932, inclusive. (4) For years 1924 to 1932, inclusive. (5) For years 1922 to 1928, inclusive. (6) St. Louis selling price — average selling price for each company is weighted according to company yearly production, based on average price for each year; also the average of all companies is weighted according to total production of each company.

II—Based on Total Dividends Plus Interest on Bonded Indebtedness

Mining Companies:	Total Production Pounds	Dividends and Interest on Bonded Debt, Dollars	Average Dividend and Interest per Pound, Cents	Average (6) Selling Price per Pound, Cents	Average Cost per Pound, Cents
Bunker Hill & Sullivan (1)	45,740,000	8,737,577	19.103	4.450	.....
Butte & Superior (2)	567,336,000	3,337,271	0.588	6.430	5.842
New Jersey Zinc (3)	1,197,420,000	38,876,714	3.247	6.455	3.208
Park Utah Consolidated (4)	269,589,000	7,345,937	2.725	6.289	3.564
St. Joseph Lead (5)	446,260,000	46,852,607	10.499	5.287	.....
Silver King Coalition	79,239,000	9,743,686	12.296	5.462	.....
Utah Apex	98,126,000	2,244,850	2.288	6.616	4.328
Totals for mining companies	2,703,710,000	117,138,642	4.333	6.290	1.957
Smelting Companies:					
American Metal	1,065,096,000	23,546,092	2.211	6.243	4.032
American Smelting & Refining	995,928,000	105,327,152	10.576	5.700	.....
Federal Mining & Smelting	*709,652,000	8,601,227	1.212	6.463	5.251
U. S. Smelting & Refining	491,624,000	32,203,821	6.550	5.789	.....
Totals for smelting companies	3,262,300,000	169,678,292	5.201	6.057	0.856
Total all companies	5,966,010,000	286,816,934	4.808	6.163	1.255
Total production in U. S.	10,782,302,000				
Per cent of total	55.3				

Notes: (1) 1928 to 1932, inclusive. (2) 1922 to 1930, inclusive. (3) 1922 to 1928, inclusive. (4) 1923 to 1932, inclusive. (5) 1924 to 1932, inclusive. (6) St. Louis selling price — average selling price for each company is weighted according to company yearly production, based on average St. Louis price for each year; also the average for all companies is weighted according to the production of each company.

III—Based on Net Earnings

Companies:	Total Production, Pounds	Total Net Earnings(7), Dollars	Average Earnings per Pound, Cents	Average(6) Selling Price per Pound, Cents	Average Cost per Pound, Cents	Average Profit per Pound, Cents
American Metal	1,065,096,000	23,386,910	2.196	6.243	4.047	.....
American Smelting & Refining	995,928,000	122,344,304	12.284	5.700	.....	6.584
Bunker Hill & Sullivan (1)	45,740,000	6,947,506	15.189	4.450	.....	10.739
Butte & Superior (2)	567,336,000	982,560	0.173	6.430	6.257	.....
Federal Mining & Smelting	709,652,000	12,634,741	1.780	6.463	4.683	.....
New Jersey Zinc (5)	1,197,420,000	44,235,328	3.694	6.555	2.861	.....
Park Utah Consolidated (3)	269,589,000	6,904,059	2.561	6.289	3.672	.....
St. Joseph Lead (4)	446,260,000	39,243,291	8.794	5.287	.....	3.507
Silver King Coalition (4)	79,239,000	12,285,823	15.504	5.462	.....	10.042
U. S. Smelting & Refining	491,624,000	38,378,404	7.806	5.789	.....	2.017
Utah Apex	98,126,000	1,316,744	1.342	6.616	5.274	.....
Totals	5,966,010,000	308,659,670	5.174	6.163	0.097	.....
Total U. S. production (1922-1932, inclusive) primary zinc metal	10,782,302,000					
Per cent of total	55.3					

Notes: (1) For years 1928 to 1932, inclusive. (2) For years 1922 to 1930, inclusive. (3) For years 1923 to 1932, inclusive. (4) For years 1924 to 1932, inclusive. (5) For years 1922 to 1928, inclusive. (6) St. Louis selling price — average selling price for each company is weighted according to company yearly production, based on average price for each year; also the average of all companies is weighted according to total production of each company. (7) Take into account in most instances depreciation and depletion.

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Venezuela's Iron Deposits

ATTENTION has recently been directed to the numerous iron deposits of the Imataca Range of Venezuela, which occur along the Orinoco, in the Guayana Highlands. Some are of little importance, but others may rank with the largest masses of high-grade iron ore in the world, according to Guillermo Zuloaga, who investigated them in 1929. In geology and character the ores are like those of the large deposits of Brazil.

The Guayana Highlands are the northern extension of the Brazilian Archean shield. The latter complex consists of schists and gneisses eroded to a flat surface, on which a few scattered masses of sediments remain. Outcrops are abundant but inconspicuous. The oldest sediments found above the complex are the Imataca formation of ferruginous quartzites, itabirites, and iron ore. This is confined to a narrow belt along the Orinoco. It strikes about N. 70 deg. E. for 150 km. from Monte Cristo and then east-west until covered by the delta. Its maximum thickness seems to be about 200 meters. It must lie in places directly on the complex, but igneous intrusions have obscured the contact. Quartz, magnetite, and hematite are the formation's main constituents. The change from itabirite or ferruginous quartzites to ore is rather abrupt. The quartzite itself runs close to 50 per cent iron generally. Its outcrops are generally covered by a heavy conglomeratic layer, the "canga," which is made up of fragments of ore and quartzite cemented with iron oxide.

The ore belt is largely unexplored. Deposits found are mostly those easily accessible or where roads have cut the formation. The most westerly is at Monte Cristo, 30 km. southeast of Ciudad Bolivar. The next known is at Pao, 100 km. northeast and 50 km. from the Orinoco. North of this, on the river, are two outcrops: one, the Imperial, was prospected about 1912 by the Canadian Venezuelan Ore Company, but never mined. Next geographically is Piacoa, practically at the delta apex, also explored by the company. From here the formation outcrops at intervals along the river as far as the Imataca mines, at Manoa. Here, close to the sea, the only serious mining has been done.

Deposits with enough high-grade ore to justify economic consideration are the Pao and the Imataca.

Core-drill samples of Pao ore from depths of 35 to 425 ft. ranged from 67.52 to 71.33 in iron; 0.05 to 0.64 in silica, 0.01 to 0.118 in sulphur, and 0.13 to 0.30 in phosphorus. Three cargoes shipped from the Imataca mines, at Manoa, averaged 66.53 per cent iron; silica, 1.81; phosphorus, 0.031; sulphur, 0.045; and titanium, 0.139.

Trends and Developments In the Industry

NRA and Copper Interests Reach Agreement On a Code of Fair Practice

Anaconda States Its Objections Have Been Met—Codification of the Other Non-Ferrous Metal Industries Will Probably Follow Soon—Talc and Soapstone Code and Quicksilver Code Are Approved

AGREEMENT on a code of fair practice for the copper industry was reached late last month in private conferences of NRA officials and representatives of the industry, following public hearings on March 12-13 and March 20. Conclusion of the protracted discussions between the Administration and the copper interests was said to have resulted from the virtual imposition of a code by the Administration; but the industry, wishing to avoid being the first to have a code forced on it, reluctantly accepted the provisions proposed by the NRA.

No price fixing is attempted in the code, although the Code Authority may act on the question of prices and production in the event that an emergency exists which requires that corrective measures be undertaken. Surplus stocks are frozen, and new production is termed "Blue Eagle" copper. Surpluses may be sold for export. Production is allocated as follows: Kennecott, 6,120 tons per month; Anaconda, 3,750 tons; Phelps Dodge, 2,805 tons; United Verde, 1,292 tons; Calumet & Hecla, 1,100 tons; Miami Copper, 828 tons; Magma Copper, 625 tons; United Verde Extension, 600 tons; Consolidated Copper Mines, 567 tons; Copper Range, 525 tons. These quotas provide for a total monthly output of 18,212 tons, or an annual production of 218,544 tons.

Final revisions on the code were in progress as the month closed. C. F. Kelley, president of Anaconda, issued the following statement on March 29 relative to the objections he voiced at the hearing on March 20, when the code presented by Deputy Administrator H. O. King at the conclusion of the March 12-13 hearing was under discussion:

"It is my understanding today from the highest authorities in Washington that the matters in controversy have now been brought to a point where there is a practical agreement between the Recovery Administration and the copper industry and that the members of the industry have indicated their willingness to comply upon a voluntary basis with the requirements of the Administration. The objections of Anaconda to the provisions of the code proposed by NRA, which, if adopted, would have amounted to an absolute governmental control of private property in putting the fabricating plants owned by subsidiaries of Anaconda at the disposal of units in the industry having no outlets for their copper, have been met. Anaconda has reaffirmed its willingness upon a voluntary basis to purchase copper from others and assist in the rehabilitation and stabilization of the industry."

Summaries of the March 12-13 and March 20 hearings are appended.

Once the copper code has been signed and the industry is operating under its provisions, prompt codification of the lead and zinc industries is generally expected.

During March the code for the quicksilver industry was approved, and also that for the talc and soapstone industry. The quicksilver code, effective March 31, specifies a maximum 40-hr. work week, with exceptions. Minimum wages are 42½c. per hour except in Texas, Arkansas, Louisiana, Mississippi, Tennessee, and Alabama, where the rate is fixed at 30c.

The talc and soapstone code, effective March 31, specifies a maximum work week of 40 hours with exceptions, and with 48 hours permitted during six weeks of any six months' period for seasonal demands. Minimum wages are 40c. per hour underground and 35c. per hour above ground in the Northern zone and 30c. per hour underground and 25c. above ground in the Southern zone. The Southern zone is defined as including Virginia, Tennessee, North Carolina, Georgia, and Alabama.

Copper Code Hearing, March 12

Senators Ashurst and Hayden and Representative Isabella Greenway, of Arizona, appeared in opposition to the copper code proposed by the industry at the opening of the public hearing held on March 12. However, they urged the speedy adoption of some other code, more fair to workers and less biased in favor of mine owners. Senator Ashurst said the President should promulgate a code if the industry cannot agree upon one.

H. O. King, Deputy Administrator, and L. S. Tailer, Assistant Deputy, presided.

A. E. Petermann, President of the United States Copper Association, presented and sponsored the code.

Copper Code Hearing, March 13

Assistant Deputy Administrator C. S. Craig presided as the hearing resumed on March 13.

William B. Daly, manager of mines for Anaconda, read a lengthy brief in refutation of charges made the previous day by Thomas Brown, labor union official, regarding working conditions and safety precautions in the Anaconda mines.

The influence of the New York Commodity Exchange was thrown against the code in a statement made by Donald Marks, who objected strenuously to the market allocation plan and the provision against selling below cost. He contended that the market for copper should be left "free and open" and predicted any attempt to restrict sales and influence prices would end in failure "just as every attempt of the kind has failed whenever it has been tried anywhere in the world." Deputy Administrator H. O. King arrived to take charge of the hearing, and he questioned Marks at some length regarding the interest of the New York Commodity Ex-

Zinc Institute Meets At St. Louis, April 30-May 1

The sixteenth annual meeting of the American Zinc Institute will be held at St. Louis on April 30 and May 1. A feature of the meeting will be a discussion of the Zinc Code. A complete report on this subject will be made, followed by an open discussion of the code and its relation to the various branches of the zinc industry. Full reports of other Institute activities, especially the Better Galvanizing Campaign, will also be made.

change in the code and the commission it receives on sales.

A. E. Petermann, counsel for the United States Copper Association, sponsoring the code, said in reply to Marks that while the industry's first recovery step must be to control production, this control necessarily had to be measured to meet the national emergency and keep men at work. He declared current production thus must be given first right to the current market. He defended the marketing allocation plan embodied in the code. The code hits the commodity exchange, he asserted, because the industry's plans contemplate deferring sales of old copper stocks to give priority to current production. He insisted the exchange should properly come under the code for "anybody who buys for resale is in the copper business." He pointed out, however, that the code does not attempt to include the exchange, but covers only those engaged in the production of copper.

F. H. Brownell, chairman American Smelting & Refining Company, said "Parceling of sales is the only way out. The solution is not by way of an open market." Discussing, generally, the marketing of various metals, not merely copper, in terms of world markets, he did not favor the so-called "open market" for American, however much might be said in its favor for metal markets of London and the Continent, where by a "hedging" system the speculative element is minimized. He considered that the plan of "producers of copper keeping in touch with consumers of copper and thus knowing what the consumption demand is" works best for America.

W. Parsons Todd, New York, president of Todd, Inc., dealers in copper and a member of the Commodity Exchange, opposed the code rules being so strict, in production and marketing aspects, as to "force the closing of the exchanges."

Arthur W. Millhauser, president of the Millhauser Trading Corporation, New York, also defended the speculator, who, he believed, has a useful function to perform and "is not as harmful as he has been described." He suggested that if the copper producers are losing money at 8c. a pound they might find it cheaper to close the mines, "put the men on a dole, unemployment insurance, pension, or whatever you want to call it" until the present surplus copper stock is absorbed and the mines can resume profitable operation to supply current consumption demands.

An appeal that President Roosevelt himself, under authority of the National Recovery Act, write and promulgate a code for the copper industry—"if the interests concerned cannot agree upon a code"—was made by Hoval A. Smith, Warren, Ariz. He represented three producing, developing, and prospecting copper associations of Arizona.

C. W. Van Dyke, Arizona Domestic Copper Producers Association, suggested allocation of copper production by states, which he thought could materially increase employment by reviving the industry.

Dr. J. S. Gould, Labor Advisory Board, said the industry's proposed code was unsatisfactory. He opposed its averaging of hours provisions, which he said would not relieve unemployment. He asked for shorter hours than the code's 40-hr. maximum and time and one-half for all overtime. He called the proposed code's wage scale "entirely inadequate." He proposed that an Industrial Relations Board be set up for the copper industry, membership equally divided between employers and employees and with an impartial chairman to render decisions in case of deadlock.

At this junction Deputy Administrator King said that evidently the serious problems of the copper industry are not solved by the code proposed by the industry. He said the difficulties in attempting to formulate a copper code have been tremendous, and "in an effort to suggest something of assistance some members of the Recovery Administration who have been working on this problem for months have written a code, for the consideration of the industry and not as representing the final opinion of the Administration." After outlining the salient features of the Administration's suggested basis for a code, Deputy Administrator King adjourned the hearing until March 20, to afford opportunity for all interested to study the new proposed code.

Copper Code Hearing, March 20

The proposed copper code was opposed by a variety of interests at a resumed public hearing held on March 20 before Deputy Administrator King.

Senator F. Ashurst and Congresswoman Isabella Greenway, of Arizona, asked for a code that would really put copper miners back to work, which they believed no code so far proposed would do.

John L. Lewis, president United Mine Workers of America, said the minimum wage should be at least $5 per day, and that an 8-hr. day was too long. The proposed code's provision for averaging an 8-hr. day over three months' periods he considered such an obvious evasion of the entire purpose and spirit of the New Deal that he did not see how the NRA could consider it, or anybody think the President would sign it. Under such a system men would work any number of hours per day, and then be laid off entirely, to make the 8-hr. average, he pointed out.

D. M. Kelly, attorney, representing the Anaconda Copper Mining Company, Butte, Montana, protested the code and said:

"The Anaconda Copper Mining Company is willing to cooperate with the Administration and with the members of the industry to the end that the copper industry be stabilized. In this connection, it is and at all times has been willing to enter into voluntary agreements with members of the industry, and to cause its owned and/or controlled fabricating plants to enter into voluntary agreements in common with their competitors in the fabricating industry, for the purpose of furnishing buying power on a reasonable and fair basis.

"However, the Anaconda Copper Mining Company protests against a code of fair competition for the copper industry on the basis of or containing the principles of the suggested code submitted by Mr. King, the Deputy Administrator, at the close of the hearing on March 13, 1934, on the following grounds:

"1. The suggested code with said substitute provisions subjects the business of the Anaconda Copper Mining Company and its subsidiaries, the American Brass Company and Anaconda Wire & Cable Company, to a Code Authority controlled by its competitors. The interests of such competitors are directly antagonistic and adverse to the interests of the Anaconda Copper Mining Company, and neither they nor their appointees should be permitted to control its business and that of its subsidiaries.

"2. The sales plan proposed constitutes a dedication of property interest of the Anaconda Copper Mining Company to the benefit of the other members of the industry, without any provision for compensation.

"3. The suggested code with its substitute provisions is arbitrary and especially discriminatory with respect to the Anaconda Copper Mining Company and its subsidiaries.

"4. The suggested code with its substitute provisions is further discriminatory since it seeks to regulate the business of the American Brass Company and the Anaconda Wire & Cable Company, which are now subject to codes approved by the President for their respective industries, without subjecting their competitors to similar regulation.

"5. The suggested code with its substitute provisions assumes that the Anaconda Copper Mines owns the property of the Anaconda Wire & Cable Company, whereas approximately 37 per cent of Anaconda Wire & Cable Company is owned by the public, and the remainder by Anaconda Copper Mining Company.

"6. The suggested code impairs the obligations of existing contracts and requires the Anaconda Copper Mining Company or its subsidiaries to apply a proportion of the benefits thereof to members of the copper industry.

"7. The Anaconda Copper Mining Company submits that under normal business conditions the plants of its wholly owned subsidiary, the American Brass Company, are able to consume in the business of fabricating copper and brass products, the entire output of the mines of the Anaconda group in the United States; that such subsidiary and fabricating business are now subject to the code approved by the President for the Copper and Brass Mill Products Industry, and that therefore neither the American Brass Company nor Anaconda Copper Mining Company should be subject to a code for the copper industry; that because of the difference in the character of the business of producers of copper in the United States, it is impossible to adopt fair rules and regulations with respect to those companies having both mine and fabricating capacity, where the fabricating capacity exceeds the mine capacity, those companies having fabricating capacity less than the mine capacity, and those companies who are without fabricating facilities. The proposed code of fair competition submitted by the United States Copper Association provides that limitation of production and allocation of sales shall be made only by voluntary agreement and for that reason was assented to by Anaconda Copper Mining Company. Said company objects to a code for the copper industry, of which it is not properly a part, which imposes an allocation of sales upon the basis not of fabricating capacity, but of mine capacity, which includes in sales the sales of fabricated articles, and which allocation does not bear any relation to sales capacity, ability or organization, nor to past or future sales.

"8. The suggested code with said substitutes does not tend to increase employment, nor otherwise accomplish the purpose of the National Industrial Recovery Act.

"9. The suggested code with said substi-

tutes is invalid among other reasons in that it requires assent to the code for the purpose of obtaining a sales quota, and prohibits sales except in accordance with the sales quota. Thus, in case of failure to assent, the code seeks to deprive a member of the right to make sales and seeks to impose penalties for violation of its provisions.

"10. The suggested code with said substitutes is not a code of fair competition within the contemplation of the National Industrial Recovery Act and is contrary to the provisions thereof.

"11. The suggested code, if adopted, would be invalid and illegal."

H. M. Owen, another attorney for the Anaconda group, and representing blocs of stockholders, objected upon similar grounds.

William J. Donovan, attorney for stockholders of the American Wire & Cable Company, an Anaconda subsidiary, filed a brief setting forth objections of the same nature.

C. F. Kelley, president of the Anaconda Copper Mining Company, its subsidiaries and affiliates, took the stand and argued in support of the position expressed by the attorneys. He said the Anaconda group, with the biggest investment of any outfit in the copper business in this country, would, under the proposed code, be at the mercy of a Code Authority dominated by its competitors.

Mrs. Isabella Greenway, Arizona Congresswoman, expressed the hope that the Anaconda officials would "join the United States government in this effort to rehabilitate the copper industry," and the belief that stockholders of that company would rather do this than "possibly lose their entire investment."

J. M. Hadley, Consumers Advisory Board, said it was important that the copper industry be maintained as a going concern, and offered amendments changing the set-up of the sales plan of the proposed code, increasing the membership of the Code Authority, and providing for consumer representation thereon.

C. S. J. Trench, of New York, representing the *American Metal Market*, a trade publication, asked for code provisions to insure that price lists, under the code, would be "open to the inspection of anyone at all reasonable times." This was to insure the newspapers getting adequate information of prices under the code set-up.

James E. Pope, of New York, Pope Trading Corporation, which deals in copper, among other things, asked that the code do not "destroy the New York Commodity Exchange."

Cleve W. Van Dyke, of Miami, Ariz., president Arizona Copper Producers Association, thought the code as proposed did not provide adequate protection for labor.

John M. Tobin, vice-president International Brotherhood of Blacksmiths, Drop Forgers and Helpers, asked a 30-hr. week and minimum wages ranging from $36 to $72 per week.

Donald Myers, of the New York Commodity Exchange, testified again to the effect that "open trading" on an "open market" is desirable, and that commodity exchanges "serve a real economic purpose" and should not be put out of business by the code.

The meeting was then adjourned indefinitely.

New headframe at the Ross shaft of Homestake Mining, at Lead, S. D., nears completion. Construction of the new headframe and shaft is part of the company's "public-works" program, which has given employment to 300 additional workers

Several Mexican Operations At Higher Levels

Cia. de Inversiones del Oro is mining 580 tons of gold-silver ore daily at La Noria, Zacatecas, and is treating it at a 600-ton flotation plant. . . . Arrangements are being made by Sinaloa Premier Mines to install a 200-ton flotation plant. . . . A daily production of 80 tons of gold, silver, lead, zinc and copper ore has been attained by Cia. La Quimica y Anexas, operating near Toluca, Mexico. . . . Work has been started at the Polar Star mine, about 15 miles south of Todos Santos, Lower California, by Alvin B. Carpenter, consulting engineer, of Los Angeles, Calif. . . . Cia. Minera Los Reyes, at Nacozari, Sonora, is mining 35 tons of gold and silver ores daily. . . . Fresnillo Mining has arranged for the installation of a 4,000-volt electric power line from its Nevada mine to Fresnillo, Zacatecas.

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Mount Morgan Increases Output

To take full advantage of the high gold price, Mount Morgan, which is operating by open-cutting and flotation at the old Mount Morgan mine, Queensland, has decided to increase its output from 3,000 to 5,000 tons weekly. Overburden is to be removed at the rate of 8,000 tons a week, and reconditioning of the power house is to be undertaken. Current recovery is much higher than originally anticipated.

Three New Alluvial Operations In Victoria, Australia

Three companies with English capital have been formed recently to work deep leads at Avoca, Victoria, Australia. Talbot Alluvials will work the leads at the old Carralulup mine, near Talbot. The main shaft has been unwatered and the mine is being prepared for extraction. Homebush Gold Mining and Madam Hopkins Gold Mining have each been floated with a capital of £300,000 in 5s. shares to work other sections of the main lead system. Operations of these two companies will be governed by the results obtained by the Talbot Alluvials. Oroville Dredging and Mount Elliott, Ltd., are the principal shareholders in these new companies.

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Nigel Gold to Reopen in May

Nigel Gold Mining, which was supplied a year ago with funds to reopen the old mine on the Far Eastern Rand, is expected to start production in May, and to have its operations in full swing about a month later.

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Molyneux Gold to Start Soon

Molyneux Gold Dredging has raised the capital required to start dredging an area covering about 19 miles along the Molyneux River, in New Zealand, at a point about 137 miles by rail from Dunedin.

Outlook for the Mining Industry Improves Throughout the United States

LAST MONTH saw a substantial improvement in mining activity throughout the United States. Basically, this development was probably the result of material betterment in general economic conditions. Seasonal influence also undoubtedly entered into the situation.

Reports from the various mining districts reveal increasing employment of mine workers, reopening of many old camps—including one in Nevada where Mark Twain tried his luck—and the inception of a large number of new ventures, including several of fair proportions. Among the announcements of increased operations was that of Phelps Dodge, to the effect that, owing to the corporation's heavy sales abroad, its output would be raised by about 50 per cent.

Continuation of the current expansion in mining activity is generally expected, with settlement of problems coincident with codification of the various branches of the mining industry materially aiding in bringing about a return to better days in mining communities.

A summary of the more important developments in the mining districts of the various states follows:

Utah

The outlook for the mining industry in Utah has been appreciably brightened by the increase in the dividend rate by Tintic Standard and the resumption of operations at a number of old properties. On the strength of the advanced price for silver, Tintic Standard directors decided that increase of the dividend rate from 5 to 7½c. a share would be justified in the payment for the first quarter on March 31. Eureka Standard paid the usual 3c. dividend on the same date. Silver King Coalition Mines paid 15c. a share, or $183,070, on April 2.

During March, the Utah Apex mine, at Bingham, which had resumed operations hardly a month before, increased production to 1,000 tons a month and the number of employees to 55.

A better showing is being made at the Eureka Lilly property, in the East Tintic district, where work is being centered on the 800 and 900 levels. The men are guaranteed $3.50 a day before the company participates in any profits. The report is current that during January employees averaged $5 a day.

The Dividend terminal of the North Lily mine tramway, which was destroyed by fire recently, has been replaced with a fireproof structure and put in condition for operation, greatly facilitating the handling of ore.

Another old producer to resume operations is the Moscow Silver, in the Star district, near Milford. At this property, ore from a drift on the 1,600 level is being stored for shipment. A raise from the 900 level is in carbonate ore.

At the property of Tintic Prince Mining, in Iron Canyon, 4 miles north of Eureka, new equipment has been installed and living quarters have been built. A tunnel is being advanced west on a fissure to prospect a high-grade showing struck on the other side of the ridge last fall.

In the Henry Mountain district, near Marysvale, Bromide Gold Mining has a crew of ten men advancing a tunnel.

Manning Gold Mining is treating approximately 300 tons of tailing daily, at Manning, in the Mercur district, according to J. C. Ingersoll, who is directing operations. A 60 per cent recovery is being made on mill heads averaging 0.14 oz. gold to the ton. By the middle of the month, the company expects to have a sand circuit installed, consisting of three 54x20-in. Akins classifiers, with 14-in. flights and cast-iron replaceable shoes; and two 15x20-ft. agitators, with 60-in. propellers. Operation of this circuit will materially improve recoveries. The company is also planning to increase its tonnage and to treat a better grade of tailing.

Park City Development, with A. L. Hurley, manager, is mapping out an aggressive plan for shipments from its American Flag property, where ore carrying values in gold, silver, lead, and zinc is being developed.

Another important development occurred recently at Park City when Park City Utah Mines, headed by George W. Lambourne, made arrangements to work through the Star of Utah tunnel of New Park Mining. Ground of Park City Utah Mines parallels the Star of Utah tunnel for a considerable distance. By this work, both companies hope to gain geological data of value in the development of their ground. W. H. H. Cranmer is president of New Pork Mining.

Bingham mining operators are again discussing plans for a deep transportation and drainage tunnel. One plan calls for the driving of a tunnel about 3 miles northwest of Tooele, where the International smelter is situated. Another plan would undertake, as a PWA project, the driving of a 3-mile tunnel from the east side of the district, at an estimated cost of $3,000,000.

World Production of Gold

(*American Bureau of Metal Statistics*)

In Fine Ounces

	Dec. 1933	Jan. 1934	Feb. 1934
United States (*a*)	270,000	235,000	268,000
Canada	248,000	231,000	220,000
Mexico	50,000 (*f*)	55,000 (*f*)	50,000
Colombia	25,000 (*f*)	30,000 (*f*)	27,000
Other South America	47,000	52,000	50,000
British India (*e*)	28,000	27,000	25,000
Japan (*e*)	38,000 (*f*)	40,000 (*f*)	35,000
Queensland	8,000	7,000 (*f*)	8,000
Western Australia	56,000	55,000	52,000
Other Australasia (*b*)	38,000	36,000	34,000
South Africa	879,000	908,000	826,000
Belgian Congo	19,000	20,000	20,000
Rhodesia	57,000	58,000	55,000
British West Africa	29,000	30,000	30,000
Russia (*c*)	(*f*) 200,000	(*f*) 200,000	(*f*) 200,000
Elsewhere (*d*)	(*f*) 100,000	(*f*) 110,000	(*f*) 106,000
Totals	2,092,000	2,094,000	2,006,000

(*a*) Includes Philippines. (*b*) Includes New Zealand and New Guinea. (*c*) Chiefly Siberia; 1933 estimated at average rate of 1932. (*d*) Includes West Indies, Central America, Europe, and Asiatic and African lands not separately reported: estimated. (*e*) Principal mines: nearly complete. (*f*) Conjectural.

Nevada

At Mountain City, Elko County, the new three-compartment shaft of Mountain City Copper, an Anaconda subsidiary, was connected recently with the old shaft at its 400-ft. level, but work has been delayed by the sloughing of about 100 ft. of ground behind the timbers of the new shaft, now 450 ft. deep. This shaft will be continued to the 600-ft. point before laterals are driven to explore the large body of high-grade copper ore. Crosscuts above the 400 level show the orebody to be 150 ft. wide.

Options and leases on a large number of claims adjacent to those of Mountain City Copper have been relinquished by Warhorse Exploration, a Delaware corporation that employed several diamond drills in prospecting this area. The drilling units, according to reports, will be shipped to Utah, and about 7,000 ft. of iron pipe, used to convey water to the drills, will be sold. D. C. Sharpstone has been directing the work of Warhorse Exploration, which has been financed chiefly by E. C. Congdon, of Duluth.

White Caps Gold Mining, producer of complex arsenical silver ore at Manhattan, Nye County, believes that new orebodies will be found at the company's property, both laterally in the limestone and at greater depth. The management hopes to develop shortly a process to treat the ore with success. The arsenic and antimony content of the ore appears to decrease with depth.

Several cars of ore have been shipped to the Garfield smelter from the Ramsey-Comstock mine, at Ramsey, Lyon County, by Albert Burch, directing engineer for Rainier Investment & Mining. A shoot of high-grade ore has been opened at three horizons between the 400 and 600 levels. The same company is developing ground in the Silver City area, just south of the Comstock lode.

Plans involving the reopening of the Betty O'Neal silver mine, 12 miles southeast of Battle Mountain in Lander County, have been announced by N. H. Getchell, vice-president and manager for Gold Circle Consolidated Mines, which absorbed the Betty O'Neal company in 1930. The mine was closed down in 1919 because of the low price of silver, but paid dividends for some time when silver was below the current price. Its 200-ton flotation mill and mine workings have been kept in good repair, and the

first work to be undertaken will be the extension south of the lowest of five tunnels, to develop a long oreshoot opened on the surface.

Filing of deeds to a large number of mining claims at the once famous silver camp of Austin, Lander County, scene of the early Reese River stampede, has been followed by reports that the old mines below and near the town are to be reopened and worked on a substantial scale, after a generation of idleness. The properties involved are said to include the old Austin-Manhattan Consolidated, on Lander and Union hills, and the Austin-Dakota and Equity Mines groups. These at one time were the foremost producers of silver in the country.

Efforts are being made by California operators to revive the old camp of Aurora, famed as the home of Mark Twain and center of the hectic Esmeralda excitement, contemporary with the Comstock boom. Last production of the district, which was unprofitable, was by the Goldfield Consolidated Mines. This company abandoned its operations there in 1918. Several of the old mines have been acquired by O. D. Thomas and San Francisco associates through the purchase of tax titles from Mineral County. A 60-ton flotation mill has been built on the old Langtry mine, and plans for early construction of another mill on the Silver Hill group have been announced.

Consolidation of three Pioche properties—the Forlorn Hope, the Pan-American, and Pioche Coalition Mines—into one company, Comet Coalition Mines, gives the new organization control of 220 claims and the outcrop of the Combined Metals ore bed for a distance of 4 miles. Purchase of the holdings of the late James Elwood Jones, of West Virginia, by International Smelting, gives the smelting company a minority interest in Comet Coalition Mines, amounting to about 40 per cent. Thirty per cent control is owned by W. F. Snyder & Sons.

About $500,000, according to estimates, has been expended by the Snyder-Jones interests in developing the Combined Metals ore zone in this virgin section of the Pioche camp. On the Pan-American ground, an incline shaft has been driven 2,000 ft., all in low-grade ore. Both this shaft and that on the Forlorn Hope property have been equipped with modern electric and air-driven machinery. Work in the future will be concentrated on the orebody in the Pan-American ground, in the hope of finding higher-grade ore, or of developing a sufficient tonnage of low-grade ore to justify the erection of a 2,000-ton mill and the building of a railroad into the district.

Preceded by two months of development work, Nevada-Massachusetts has resumed milling operations at its Silver Dyke mine, near Mina, at the rate of 50 tons of tungsten ore a day. A force of 25 men will be employed eventually. At the Mill City plant, the company is treating about 225 tons a day, with 80 men employed. Sinking of the Humboldt shaft to the 725-ft. level is practically completed. The Stank shaft has a depth of 800 ft. and is in full operation. Ott F. Heizer is general manager.

W. F. Snyder & Sons, of Salt Lake City, are sinking a shaft on the old Windfall property in the Eureka district. A gasoline hoist and compressor have just been installed. Previously, the shaft was sunk 60 ft. by hand. The company plans to explore in the neighborhood of the old stopes and to develop new ground.

California

Preliminary work has been started at the Thorpe mine, near Angels Camp, held under a five-year lease and purchase option by Gruss Mining. The Thorpe mine was last operated from 1927 to 1930.

Operations have been suspended at the mine of Cardinal Gold Mining, on Bishop Creek, following the fire which completely destroyed the new 150-ton mill. A crew of seven men has been retained to look after the property. No definite plans have been decided upon for the future. The damage done to the milling plant was well covered by insurance.

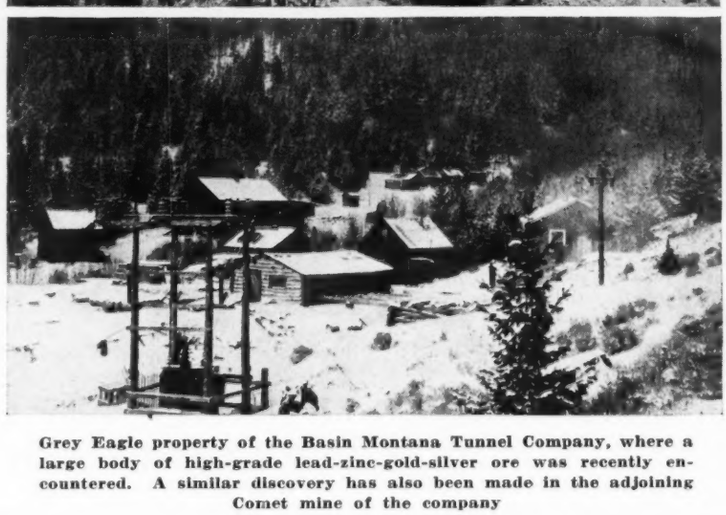
Sinking of a new shaft at a point near the mill is soon to start at the Murchie mine, near Nevada City. Capacity of the mill was increased recently by the installation of larger grinding equipment. The Murchie is owned by Empire-Star mines.

A sea-going dredge, the "Gold King," is being rebuilt at Pier 22 in San Francisco. When repairs are completed, the dredge will be towed to Alaska, where it will be used to recover gold from coastal gravel, according to reports.

High-grade gold ore has been encountered at the Morgan property of Carson Hill Gold Mines, according to reports. The discovery was made by a crew exploring the old mine, which has not been worked since the '50's.

In the Basin District, Montana's Most Active Area

Surface workings on the property of Basin Goldfields, Ltd. High-grade gold ore is being obtained from the North vein, on which sinking of a shaft is under way



Grey Eagle property of the Basin Montana Tunnel Company, where a large body of high-grade lead-zinc-gold-silver ore was recently encountered. A similar discovery has also been made in the adjoining Comet mine of the company

Arizona

W. W. Williams, of Glendale, Calif., has leased 120 acres of placer ground along Weaver Creek, near Octave, from George Thomason, of Octave, and has moved a placer plant and power shovel to the property. The Octave mine, in the same area, is being unwatered by American Smelting & Refining, after extensive diamond drilling; M. E. Pratt is in charge.

Fifty men are employed at the Hillside mine, near Bagdad, in construction of a mill in which Fagergren flotation cells will be used. At the Comstock-Dexter mine, Hillside, the shaft is to be deepened from its present depth of 136 ft. to 400 ft., with levels at the 156-, 256- and 356-ft. depths. A 250-hp. diesel power plant has just been installed. Edward L. Haff, of Los Angeles, is consulting engineer for the company. Davis-Dunkirk Mines, at Prescott, is operating its 100-ton mill, and development work is said to have added ore reserves sufficient for two years' operation. A winze has been sunk from the No. 1 tunnel and drifting has proceeded along the vein for 260 ft. No. 2 tunnel is being extended in milling ore. Compressed-air and water lines, ventilation pipe, and ore chutes have been placed in the No. 13 tunnel in preparation for mining silver ore. The company is considering the erection of a small reverberatory furnace and converter in which doré bars could be produced for shipment directly to the mint, thus eliminating transportation charges on concentrate.

Encouraged by the results of eighteen months of development work at the Democrat mine, 24 miles southeast of Kingman, in the Wallapai Mountains, the operators, Pete and Mike Vukoye, are building a small flotation mill at the property. Development work totals 1,000 ft. in three tunnels and two shafts. The gold-silver ore uncovered is estimated at 15,000 tons. History of the property dates from 1868.

A new company, known as Ajo-Papago Gold Mining, has been organized to succeed Black Bess Gold Mining, for operation of the Black Bess mine, 2 miles east of Ajo. Workings include a 200-ft. incline and drifts on two levels along the vein. Five new buildings are on the ground, but no machinery has so far been brought in. The new company plans the installation of new mining machinery and the erection of a small mill.

The Bisbee Sonora mine, 5 miles south of Naco, is shipping 25 tons of gold ore daily to the Cananea smelter. A 2,000-ft. aërial tramway and a compressor are being installed. Production is to be increased to 100 tons per day.

New producers among the leases in the Tombstone silver district include the following claims: Head Center, Dry Hill, Empire, Free Coinage, Rattlesnake, Little Joe, North and South Bonanzas, and South Chance. The Head Center claim is part of the holdings of Tombstone Development, and ore is being hoisted and milled there regularly. At Dry Hill eight men on day shift and four on night shift are mining and shipping 25 tons of ore daily. The shaft is down 140 ft., and a compressor is being installed. At the Empire claim production is also 25 tons per day. At the Free Coinage and North and South Bonanzas, and at the South Chance, cyanide plants are in operation.

Work at the Magma mine, mill, and smelter, at Superior, was placed on a basis of four six-hour shifts per day on March 1.

Montana

As in the past few months, Basin, in Jefferson County, seems to have had in March the largest mine developments in the State. Basin Montana Tunnel, besides opening a large body of high-grade ore in its Grey Eagle mine, opened a large body of milling ore in the Comet mine, on the same vein and about 2 miles to the east of the Grey Eagle. The ore in the Comet was found on the 300-ft. level, west of the shaft, and has been drifted on for several hundred feet. In width, the Comet ore averages about 48 ft. Several of the New York officers and directors visited the property during the middle of March, including Walter Phelps Jacob, managing director; William H. Hax, president; Frederic S. Allen and Allan A. Ryan, Jr. The company expects to build a flotation plant in the near future.

Basin Goldfields has started to sink on the north vein opened a few months ago. The shaft is down about 12 ft., and a gold ore of high grade is being obtained.

Philipsburg Mining, formerly the largest producer of silver at Philipsburg, Granite County, is getting ready to resume operations, according to Joseph Yob, superintendent.

Stockholders of Jardine Mining, Park County, have voted to accept the option terms of Case, Pomeroy & Company, of New York, to purchase the mine.

Clement Quinn and associates, of Duluth, have taken an option on the Golden Messenger mine, near York, Lewis and Clark County.

Minnesota

The political atmosphere at Washington changes so rapidly that the corporations controlling the iron mines in this State seem reluctant to make a final decision on the amount of ore needed at Lower Lake ports for this year. If production gets off to a May 1 start, as some predict, this decision should be announced in the near future. In the meantime, preparations continue for a busy season.

Wisconsin Steel has completed sinking the Sargeant mine shaft, to open up a new level. At the Bruce mine, at Chisholm, shaft deepening has just started. McKinney Steel is unwatering its Stevenson mine, west of Hibbing, a mine that had been full of water for more than ten years. This company is also planning to build a screening plant at its Commodore mine, in Virginia. Oliver Iron Mining is giving its large crushing and screening plants a complete overhauling, and a heavy program is under way on repairs to electric shovels and locomotives.

Oliver Iron Mining and five independent mining companies filed answers on March 17 in District Court against delinquent tax proceedings, with the declaration that the present assessed valuation of mining lands is a hostile discrimination against the owners and that taxes are partial, unequal, and excessive. Such taxes and levies violate provisions of the Fourteenth Amendment of the United States Constitution, which "forbids any State to deprive any person of property without the process of law or to deny any person the equal protection of the law." The taxes involved total $1,729,407.17 and represent the last half of the 1932 taxes on properties in nineteen iron range communities.

World Production of Silver

(American Bureau of Metal Statistics)

In Fine Ounces

	Dec. 1933	Jan. 1934	Feb. 1934
United States...	1,562,000	2,025,000	1,938,000
Canada.....	1,131,000	1,368,000	1,351,000
Mexico.....	5,391,000	(*f*) 6,000,000	(*f*) 5,400,000
Peru.....	684,000	618,000	548,000
Other America..	820,000	850,000	815,000
Europe.....	1,140,000	1,200,000	1,000,000
Australia, refined	835,000	864,000	790,000
Other Australia and New Zealand	115,000	227,000	238,000
Burma, refined..	480,000	486,000	489,000
Other Asia.....	660,000	700,000	700,000
South Africa....	86,000	(*f*) 87,000	(*f*) 85,000
Other Africa....	45,000	(*f*) 40,000	(*f*) 36,000
Total.....	12,949,000	14,465,000	13,390,000

For some of the countries the accounting, especially for the latest month, is preliminary and subject to revision, which may be considerable. The Mexican returns, which arrive late, are difficult to estimate, owing to their irregularity. (*f*) Conjectural.

Dr. J. A. Bancroft to Examine Sasare Mine for Loangwa

North Charterland Exploration reports that the Sasare mine, on its property in Northern Rhodesia, is to be examined soon by Dr. J. A. Bancroft for Loangwa Concessions. Tributors have driven adits into the hill and disclosed gold reefs which are thought to be of importance. Loangwa Concessions will start the work of prospecting the rest of the North Charterland property as soon as the dry season opens.

Langi Logan Gold Fields Formed

Langi Logan Gold Fields has been formed in London with a capital of £300,000 in £1 shares to acquire 6,120 acres of deep lead ground in the Ararat district, Victoria, Australia. The wash lies at a depth of 320 ft. and is covered with a thick layer of basalt. Two new shafts are to be sunk.

Gold Development in Northern Canada Proceeds Over a Wide Area

GOLD DEVELOPMENT of northern Canada is being conducted throughout an area 1,000 miles long and 200 miles wide. Within this expanse are more than thirty separate areas of gold-bearing rocks, where either mines are established or an attempt is being made to prove workable deposits. In nine of these gold camps, profitable operations are under way at present. Although most of the gold output continues to come from the Porcupine and Kirkland Lake camps, and as a byproduct of the base metals, several of the newer properties give some promise of becoming major producers. In the following paragraphs reference is made to some of the more prominent of the newer properties.

Ontario

The success of Howey, where current operating costs have been brought down to $1.85 a ton on 1,350 tons milled daily, has stimulated the serious investigation of other properties in the Red Lake field. Casey Summit, about 40 miles to the east, looks as if it might develop into a mine of moderate size, and Jackson-Manion, in the same locality, is preparing to mill its rich surface material and to conduct a further search for ore. Central Patricia and Pickle-Crow, about 150 miles east of Red Lake, are preparing to mill the moderate amount of ore now blocked out, with the hope that the exploration carried on concurrently will disclose additional deposits.

The area east of Lake Nipigon is very interesting at present. The 100-ton mill of Northern Empire Mines, subsidiary of Newmont, at Beardmore, is in operation. Little Long Lac Mines has developed a shoot of high-grade ore to a depth of 500 ft. and intends to install a 200-ton mill during the coming summer. Last fall, Dikdik Syndicate, organized by Alderson & MacKay, of Montreal, acquired the Johnston find, 10 miles west of Little Long Lac, and it has shipped 700 tons of high-grade ore from an open cut. A shaft is being sunk to explore the vein. At Schreiber, to the south on Lake Superior, North Shores Mines is preparing to mill high-grade ore from some narrow veins.

In the Swayze field chances are good for developing two large, low-grade mines at the Kenty and the Halcrow-Swayze. Other owners in this field are waiting for the results from these two, where underground development is being pursued vigorously.

In Michipicoten, two small mills, Minto and Parkhill, are treating profitable ore from small deposits. No large deposits have been found as yet in this or the adjoining Goudreau field.

At the McMillan, 40 miles west of Sudbury, ore has been developed to the 625-ft: level and a 125-ton mill is being installed. Power is to be supplied by a neighboring pulp and paper company at $27 per horsepower-year, the mine to meet the cost of the transmission line, estimated at $20,000.

The Manitoba & Eastern property at Timagami has shown high-grade ore in good volume in diamond-drilling to 300 ft. On the recommendation of L. K. Fletcher, consulting engineer of Bobjo Mines, which controls the property, a shaft is to be put down to this depth.

In Matachewan, Hollinger Consolidated is constructing a 500-ton mill at the Young-Davidson. About 2,500,000 tons of ore is available by open-cut, and more may be made available by underground methods. Ventures Limited is investigating the adjoining Matachewan Consolidated, where values are more segregated and may be amenable to selective mining.

Manitoba

Gods Lake Gold has installed a mining plant, by means of which it plans to prepare for milling the substantial volume of high-grade ore indicated by diamond drilling. At Island Lake, likewise in the far northeastern section of the province, ore has not yet been found below the faults that cut off the high-grade surface showing, and the mill is still idle.

Great Bear Lake

A thousand miles northwest from the Manitoba end of this 1,000-mile gold area lies Great Bear Lake, the ground between being largely unexplored, though known to consist of the Pre-Cambrian rock formations. The Eldorado silver-radium mine has been operating steadily throughout the winter, providing concentrates which will be shipped out by water and rail in July. A new find of radium ore is reported from Hottah Lake, 100 miles south of the Eldorado mine, and a large area has been staked on the snow.

Quebec

At the extreme ends of the Quebec gold belt, 80 miles apart, are the properties that have widened considerably the area for prospecting throughout northern Canada. The ore being treated so successfully in the 850-ton Beattie mill is composed of mineralized porphyry, the rock itself constituting the ore. The ore in the Siscoe and Bussieres mines, at the east end, is composed of quartz, but the quartz occurs in porphyry of similar occurrence to that of the Beattie. The other operating mines draw their ore from deposits formerly considered of the orthodox type—namely, quartz veins in the sediments or volcanics.

At the McWatters, 7 miles east of Noranda, underground development to 400 ft. has failed to show a continuance of the remarkable surface deposits, but a substantial amount of high-grade ore has been determined above the first level, that in sight totaling about 23,700 tons. A 50-ton mill is under construction, and intentions are to pursue a vigorous campaign of exploration contemporaneous with the milling of the known ore, which will last for fourteen months.

At the Arntfield, 10 miles west of Noranda, cautious exploration carried on for the past ten years has shown some small high-grade sections of ore within a large deposit of low grade. At the present price of gold, large sections of the gold-bearing zone may be ore. Drifting and crosscutting to a depth of 250 ft. are being pursued vigorously with a view to determining the average values.

At the east end of the Quebec gold belt, the Green-Stabell is milling, and the Sullivan preparing to mill, high-grade ore from small deposits. At both these properties the hope is that further exploration will disclose deposits of substantial size such as occur in the near-by Siscoe mine. The same applies to the Matthews, 12 miles to the east near the Bussieres mine, where a 50-ton mill is under construction. The most interesting property at the moment is the Lamaque, controlled by Teck-Hughes, where an extensive series of flat-dipping lenses is being developed. Three levels, down to 300 ft., have been partly developed, and shaft-sinking to 700 ft. is under way.

At the eastern extremity of the 1,000-mile gold area lies Chibougamau. Until recently, copper occurrences in this area attracted most attention, and at Opemiska Lake, 30 miles west of Chibougamau, copper-gold deposits of workable size and grade await exploitation. The present interest in gold centers round a vein at Lake Bourbeau, drilled with promising results by Noranda Mines.

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New Kalgoorlie Company Formed

North Kalgurli United Gold Development has been formed in London, with a capital of £300,000 to acquire leases totaling 95 acres at Kalgoorlie. The leases adjoin the Enterprise, being developed by Broken Hill Proprietary and the Union Jack lease of North Kalgurli Consolidated. The purchase price of the leases is £110,000, payable in cash and shares.

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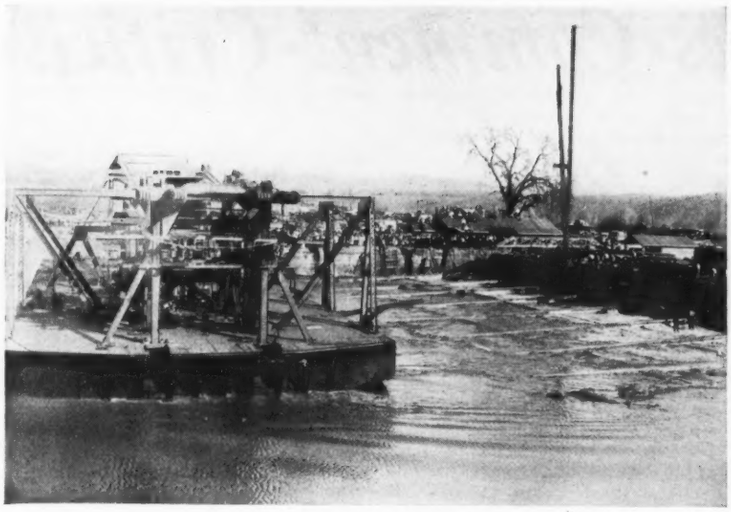
Tanganyika Concessions Options Tintax Property

Tanganyika Concessions, which, with its associated companies is largely interested in the Kakamega gold fields in Kenya Colony, has taken an option on the Tintax property, on which several veins outcrop.



Yuba Consolidated Gold Fields successfully launches the hull and superstructure of one of the largest all-steel dredges in the world, at Hammonton, Calif., on March 4. When completed, the dredge will dig 110 ft. below the water line and carry a 30-ft. bank—a total digging depth of 140 ft., the greatest ever attempted. Length of the hull is 234 ft.; the beam is 68 ft., and the depth 11½ ft. The digging ladder is 200 ft. long. Bucket capacity is 18 cu.ft.

Gold Price Revives Interest In the Piedmont Belt

Gold mining in the Southern Appalachians is receiving some serious attention from Northern and Western mining men, though little local capital is interested in this revival, writes a correspondent. In Alabama, the most important operation has been the reopening of the old Hog Mountain property by P. S. Gardner and associates, where, after a program of development, a mill has been erected and is about to go into operation.

In Georgia, although some work is still being done in the Dahlonega district, gold activity has not been stimulated to the extent it has in the Carolinas. Several minor operations are reported, however, and a geophysical survey is being made in McDuffie County.

In South Carolina, several important development operations have been undertaken by mining operators of experience, and a real test is to be made of these properties at depths of 200 ft. In Edgefield County, at the old Landrum mine, on which preliminary prospecting gave good results, a shaft is to be sunk to 200 ft. by the Southern Gold Mines Corporation, under the general direction of Harry W. Ingalls and under the immediate supervision of Moyer Smith, of the Coeur d'Alene district of Idaho. At McCormick, in McCormick County, the old Dorn mine, a famous producer of the early days, is being reopened by the North American Gold Mines, Inc., also under the general direction of Harry W. Ingalls. A shaft is being sunk below the old workings, and prospecting will be begun after a station and sump have been cut out on the 200-ft. level. In the original operation considerable rich ore was obtained; high-grade footwall ore was encountered in the reopening operation. Some good-grade complex veins carrying lead, zinc, and copper and a fair amount of gold and silver were also cut near the bottom of the present workings. South of the shaft is a manganese iron gossan of interesting possibilities.

At the old Pioneer mine, about 2 miles from McCormick, the Carolina Mines Exploration Company, under the direction of W. A. White, has reopened the old Smith mine, and is operating a small cyanide and flotation mill.

In York County, two important prospecting operations are in progress near Smyrna. One, the Bar-Kat Mining Company, under the direction of J. R. Elmendorf, is prospecting the old McGill mine, having sunk the shaft to 200 ft. and begun crosscutting in both directions; diamond drill explorations below this horizon are planned. The old Terry mine was recently optioned by H. A. Guess, vice-president and general manager of the mining department of the American Smelting & Refining Company, of New York. This is not a company operation, however, but a personal investment of Mr. Guess and is under the direction of his son and Robert Baldwin, one of the former lessees of this property, from which several cars of high-grade ore were shipped last autumn. A shaft is being sunk to 200 ft., from which a prospecting campaign will be undertaken. At Smyrna, a custom amalgamation-and-flotation mill is being erected by Howard Venable, under the title of the White Star Mining Company. At Hickory Grove, the Piedmont Assay Office is doing assaying for the many prospecting operations in the Piedmont Belt. About two miles from Hickory Grove, Meyer & Austerman are cyaniding by percolation the old tailing dump of the Magnolia mine, which property may also be prospected shortly. The kyanite deposit at Henry Knob, near Clover, has been sampled and may be operated in the near future.

In North Carolina, the most important recent event was the optioning of the Long Creek mine, in Lincoln County, by H. A. Guess, who will dewater and explore the property. The old Coggins, or Rich-Cog, mine near Eldorado, Montgomery County, is to be pumped out and explored by British interests, according to reports. Canadian interests are said to be pumping out the old Capps mine, near Charlotte, in Mecklenburg County. Many other gold properties in the Piedmont Belt are being explored, and interest in non-metallic minerals is also active. In Virginia, Western mining interests are reported to be securing favorable results in the development of wide low-grade gold veins.

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Mining in British Columbia Continues to Expand

Helena Gold Mines, which last year acquired control of Georgia River Gold Mines, in the Portland Canal area, has recently acquired an option on the Van Roi mine, a silver-lead-zinc property in the Slocan area, which is stated to have two years' supply of ore and is equipped with a 100-ton mill that can be modernized at small expense. The company's engineer has recommended further development of the Georgia River gold mine, which he considers to have promising possibilities.

In the Hope area, the large-scale exploration program of the B. C. Nickel Company is being actively prosecuted, and a main development tunnel has been driven more than halfway toward the point at which it should encounter the downward extension of the principal deposit indicated by diamond drilling and surface exploration. A second tunnel, designed to develop other orebodies, has penetrated a body of massive pyrrhotite containing nickel. In addition, further diamond drilling is being done; and work has also been started in clearing land for a town and millsite. In the same district, in the Coquihalla area, the capacity of the mill at the Dawson gold mine is being increased to 50 tons a day, and at the Pipe Stem property of the Home Gold Company drifting on the bottom level has proved the extension of commercial ore having a width of 8 ft. over a distance of 120 ft. Early erection of a mill is planned.

At Phillips Arm, Hercules Consolidated Mining is installing power machinery for the development at depth of two parallel veins of considerable width that have been exposed at the surface.

Personal Notes·Comment·Criticism

A. W. Allen is at Placerville, Calif.

Sydney A. Mewhirter has returned to Denver after spending several years in the U.S.S.R.

Richard Harvey is expected to return to England from West Africa in the near future.

Sydney H. Ball, who recently returned to New York from Cuba, is in Utah on professional work.

W. J. Hamilton, who has been seriously ill, is now recovering satisfactorily at his home in Montreal.

H. L. Tedrow has been appointed superintendent of the London Gold Mines Company at Alma, Colo.

Charles Hardy, after spending about two and a half months in Europe, returned to New York recently on the "Berengaria."

Lester W. Strauss has returned to New York after spending three months in southeastern Venezuela in mine examination work.

R. J. Lemmon, metallurgical engineer, Imperial Chemical Industries, Ltd., London, is on a visit to New York, Canada, and Australia.

Tasker L. Oddie, formerly United States Senator from Nevada, has been elected president of the Gold Mining Association of America.

E. V. Peters was elected a vice-president of the St. Joseph Lead Company at a meeting of the board of trustees held on March 8.

Ira B. Joralemon and **Frank L. Sizer,** consulting engineers, San Francisco, have returned to San Francisco after a business trip to New York.

Dr. Anton Gray, geologist, well known for his work in the Rhodesia copper district, left London late in March for America on professional business.

Walter McLaren, of Dayton, Ohio, has taken over a group of claims at Cooke City, Stillwater County, Mont., and expects to operate them this spring.

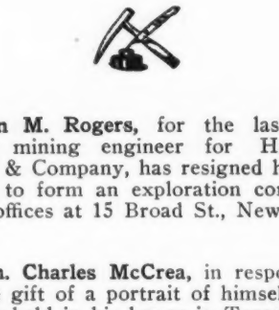
J. W. Littleford, concentrator superintendent of Roan Antelope Copper Mines, Ltd., has been granted a long leave of absence. He is proceeding to America by way of the Orient.

Walter D. Abel, who has been for some weeks in the Urique area of Chihuahua, Mexico, on mine examination work, plans to return to Los Angeles in April.

John D. Galloway, formerly Provincial Geologist of British Columbia, has established headquarters for consultation in mining engineering at 224 Pacific Building, Vancouver, B. C.

John M. Rogers, for the last five years mining engineer for Hayden, Stone & Company, has resigned his position to form an exploration company with offices at 15 Broad St., New York City.

Hon. Charles McCrea, in responding to the gift of a portrait of himself at a dinner held in his honor in Toronto recently, predicted that Ontario would have a gold output worth $100,000,000 in 1936.



Enoch Perkins

Enoch Perkins, manager of mines for the Mutual Chemical Company of America, New York, is leaving in April for a visit to New Caledonia via England and the Continent. He expects to return to New York in early December. In the meantime his address will be Boite Postale 37, Noumea, New Caledonia.

Dr. Francis A. Thomson, head of the Montana School of Mines and the Montana Bureau of Mines and Geology, has been appointed head of the mineral division of the Northwest planning board under NRA.

Wylie L. Graham, junior partner of T. H. Graham & Sons, has returned to Seattle, Wash., after an absence of six months in Chile, where he was in charge of aerial tramway operations at Braden Copper Company.

Walter E. Gilbert, pilot for Canadian Airways, has been awarded the McKee trophy in recognition of sixteen years of flying in military and civil life. Mr. Gilbert has recently made some notable flights in the Great Bear Lake region.

Charles W. Henderson has returned to the Denver office of the United States Bureau of Mines, after having spent three months in Washington in the planning and research division of NRA with respect to non-ferrous metals.

Sir Robert Williams, Bart., managing director of Tanganyika Concessions, Ltd., and a director of Union Minière du Haut-Katanga, is in Africa. While there he will visit the Kakamega gold field, in which several companies with which he is connected are largely interested.

Philip D. Wilson, who has returned to New York from a trip to northwestern Ontario, was recently elected vice-president of Pardners Mines Corporation, of which **J. G. Baragwanath** is president and **H. E. Talbott, Jr.,** is chairman of the board.

M. C. Haas, who had been acting as chief engineer for the South Dakota Civil Works Administration during the last few months, has assumed the superintendency of the Presidio mine of the American Metal Company of Texas at Shafter, Tex.

W. R. Wade, vice-president of the Engineers' Exploration & Mining Corporation, has gone to Utah and Idaho to inspect operations at several of the mines in which the Corporation is interested. He expects to be back in New York in April.

H. Y. Eagle, who is associated with **Archer E. Wheeler,** has returned to the United States from an eight-week trip to England, to which country he had gone to buy equipment for the new 100-ton Rhokana Copper refinery which is being designed by Mr. Wheeler.

Harlowe Hardinge, vice-president and general manager of the Hardinge Company, after a brief stay in San Francisco left for Colorado, where he will supervise the installation of a Hardinge-Hadsel mill at the Slide mine in Left Hand Canyon, Boulder County.

Henry Krumb, vice-president and a director of the A.I.M.E., and chairman of the Institute finance committee, was honored on Feb. 12 by the Alumni Association of Columbia University, his alma mater, by the award of a medal for services to Columbia.

Robert J. Jowsey, president of Ontario Prospectors and Developers' Association, urged recently in his annual report that the provincial regulations against fraud in the sale of mining securities be enforced to the utmost, in the interests of legitimate mining development.

Robert A. Kinzie, consulting engineer to the Santa Cruz Portland Cement Company, has been elected chairman of the San Francisco Section of the A.I.M.E. Members of the executive committee include **Chas. M. Romanowitz, Alfred Busey, Jr., James G. Parmelee,** and **Herbert A. Franke.**

H. D. Bailey, author of the article on "Ore Genesis at Meadow Creek Mine,"

presented in this issue, was graduated from the Oregon State College in 1927. He has been employed as engineer and assayer for the Yellow Pine Mining company at Goodsprings, Nev., for the last four years.

Colonel Lucien D. Beckner, geologist, of Louisville, Ky., has been honored by designation as a fellow in the American Association for the Advancement of Science. He is a member, and was formerly president, of the Kentucky Academy of Science and an authority on the subsurface geology of his State.

Samuel Barker, Jr., Butte, was elected chairman for the ensuing year at the annual meeting of the Montana section of the A.I.M.E.; **Russell B. Caples,** of Great Falls, was elected vice-chairman. **William Wraith, Jr.,** of Anaconda, and **Dr. A. M. Gaudin,** of Butte, were elected to the executive committee.

H. C. Rickaby has been appointed the Provincial Geologist of Ontario. Mr. Rickaby has prepared reports on several of the minor gold areas of Ontario, and will now complete a comprehensive report on the Sudbury nickel area on which he and his late chief, A. G. Burrows, worked for three years.

George A. Clothier, for many years on the staff of the British Columbia Department of Mines as a resident engineer, has resigned to accept a position as engineer for and managing director of the Dictator Gold Mines, Ltd., that has been organized to operate a silver-gold property in the Lightning Peak district of British Columbia.

John Van Nostrand Dorr left New York for Europe on March 28 on the "Manhattan" to be gone five or six weeks. During his stay abroad he will attend the International Congress of Pure and Applied Chemistry in Madrid, acting as official delegate of the National Research Council and the American Institute of Chemical Engineers.

Sir Edmund Davis has left London for Africa on a tour of inspection. He is chairman of Loangwa Concessions, Rhodesia Broken Hill, and Bwana M'Kubwa, vice-chairman of Rhodesian Anglo American, a director of Rhokana Corporation, British South Africa Company, and numerous other companies. He has been prominently identified with Rhodesian mining for over forty years, and is said practically to control the world's chrome production.

Walter RuKeyser has become interested, with **Howard Fields,** in the development of the McCabe-Gladstone mine, at Humboldt, Ariz. The mine is owned and operated by the Harbud Company, in which Mr. RuKeyser is a director and an officer. A 200-ton flotation plant was finished on March 3, and has operated on a three-shift basis ever since. Mr. RuKeyser expects to go to California sometime this month, returning to New York early in May.

John Herman, of Los Angeles, Calif., was honored on March 9 by having the degree of doctor of science conferred upon him by Charles University, Prague, Czechoslovakia. Mr. Herman went to Prague last September at the invitation of Dr. J. Heyrovsky, the inventor of the polarograph and the head of the department of physical chemistry at the University, with whom he was associated there during the period of his visit. His doctor's thesis dealt with the determination of gold by means of the polarograph. Mr. Herman passed through New York on April 2 on his way home.

Robert Early Phelan, of Winnipeg, Man., general manager of Hudson Bay Mining & Smelting Company, Ltd., was awarded the Inco Platinum Medal of the Canadian Institute of Mining and Metallurgy at a luncheon held in Quebec on April 3, as part of the Institute's 35th annual convention. The award, which is for distinguished service to Canada's mineral industry, was conferred on Mr. Phelan for his leadership in the development of the Flin Flon mine, in northern Manitoba. Mr. Phelan was born in Memphis, Tenn., in 1886. He graduated in 1910 from the Columbia School of Mines. His early experience was in the mines of Utah and Colorado. In 1919 he became a member of the A.I.M.E. and more recently of the Canadian Institute.

OBITUARY

E. W. Gilman, vice-president and general manager of Canadian Ingersoll-Rand Company, died suddenly in Montreal on Feb. 20 at the age of 65.

Ole Reien, one of the first men to operate a diamond drill on the Mesabi range and first president of Bovey, Minn., died recently at the age of 76.

R. P. Rogers, formerly manager of Coniagas Mines, who organized the Canadian railway battalion for service in France, died on March 1 at Petewawa, Ont.

Dr. Floyd B. Wilson, mining promotor, author, and lawyer, who had long been identified with mining interests in the West and in Mexico; at New York, on March 28; aged 84.

Paul S. Kurtzman, long prominent on the Mesabi iron range, and superintendent of the Albany and Utica mines of Pickands, Mather & Company, died recently at Hibbing, Minn., at the age of 51.

Charles F. Spilman, a member of the staff of the *Nevada State Journal,* and editor of the *Nevada Mining Journal,* and for some years a valued contributor to the news pages of *E.&M.J.,* was killed on Feb. 28 when his skull was fractured in a collision with an automobile. Mr. Spilman was 67 years old. He had long been recognized as a distinguished journalist and an authority on mining matters of the West.

James H. Hensley, Sr., died on March 12 in Miami at the home of his son, James H. Hensley, Jr., assistant manager of the Miami Copper Company. Mr. Hensley, who was born in Kentucky 82 years ago, was prominent in Colorado mining and business circles for more than half a century until ill health forced his retirement fifteen years ago. For the last four years he had made his home in Glendale, Calif.

Dr. Walter Rosenhain, F.R.S., fellow and past president of the Institute of Metals, London; at his home at Kingston Hill, Surrey, England, on March 17; aged 58. In 1908 Dr. Rosenhain was appointed first superintendent of the department of metallurgy and metallurgical chemistry at the National Physical Laboratory, a post which he held for 23 years. He resigned in 1931 to take up private practice in London as a consulting metallurgist.

Major James Mackintosh Bell, geologist, mining man, and author, at Almonte, Ont., on March 31; aged 56. After graduating from Queen's University, Major Bell took a post-graduate course at Harvard. He then spent four years as assistant field geologist for the Dominion of Canada, later becoming field director for the Ontario Bureau of Mines. Major Bell served throughout the War in the Canadian forces, retiring in 1919 as Major of the Royal Highlanders of Canada.

Mexico's Immigration Laws

The Editor:

As you invite correspondence on the subject, permit me to say, as one who has recently been through the procedure, that "Mining Engineer's" lament on the subject of the immigration laws of Mexico, in your February issue, was distinctly amusing, in that he apparently presupposed that Mexico would be willing to continue indefinitely the policy of allowing her natural resources to be exploited by foreigners for foreign benefit. No doubt custom and long usage indicated that such might be the case, but of late years the government has attempted to conserve these resources—which are still of immense potential value—for the use and benefit of its own citizenry. This policy of conservation is not at all at variance with that of the United States, where the immigration laws are not only the most stringent and exclusive imposed by any government in the world, but whose laws in regard to immigration were, I think, put in effect prior to those of Mexico.

If "Mining Engineer" will approach the problem from the point of view of fairly sharing the possible benefits of the venture with the Mexican people, he will in my opinion have little trouble in surmounting the present difficulties. In this I do not mean by payment of taxes, which are, indeed, quite reasonable, nor by employing a few Mexican laborers at the pitifully inadequate wages current here, but in a spirit of cooperation with the Mexican people, to the end that they may acquire a fair and just share in the proceeds from their own property.

ANOTHER MINING ENGINEER.

BOOK REVIEWS

The New Lindgren

MINERAL DEPOSITS. Fourth Edition. *By Waldemar Lindgren. McGraw-Hill Book Company, 330 West 42d St., New York. Pp. 930. Price $6.50.*

In addition to the usual revision, this latest edition of the leading work of the day on ore deposits has been completely reset, assurance of which may be had from the fact that the printer has set the new type in wider measure. The revision is characterized by the frequent insertion of new material, the occasional omission of passages that have become unnecessary, and by the complete rewriting of short sections at times, especially where theories of ore genesis are concerned. Similarly with illustrations—a few have been left out, a few new ones added, and, rarely, a cut has been remade to smaller size. Random instances of addition of new matter are: the paragraphs on diamond placers; the notes on the Texas-New Mexico potash area in the chapter on deposits formed by evaporation; the notes on genesis of sedimentary copper ores; and those in the chapter on lead and zinc deposits in sedimentary rocks which bring the discussion on the origin of Mississippi Valley deposits up to date, the author saying in conclusion, "The problem is not yet solved." In the chapter on mesothermal deposits, some pages on the copper deposits of the Belgian Congo and Northern Rhodesia and paragraphs on the Britannia mines in British Columbia have been added, and in the chapter on hypothermal deposits, after rewriting the section on the gold-quartz veins of Ontario, Dr. Lindgren has added new matter on gold-copper deposits. In the chapter on epithermal deposits, the section on metasomatic processes has been in part rewritten; likewise the chapter on deposits of native copper, which is then transferred to a new place between the two chapters on epithermal and mesothermal deposits respectively. The rearrangements of certain chapters is especially noticeable. For example, the pages on deposits resulting from regional metamorphism have been transferred to the back of the book and notes on plastic deformation of minerals and post-mineral reactions added. The old chapter on hematite deposits of the Lake Superior region, prefaced with two pages on processes involved, is given a new place. In it the succession of the Pre-Cambrian is presented in greater detail; the end of the chapter has been rewritten, and notes on other occurrences in the United States and on the Michipicoten range, in Canada, added; likewise pages from old Chapter XXXII on other regionally metamorphosed iron ores, including those of Sweden, Norway, and Brazil. Of interest also is the transfer of notes on Katanga copper from the chapter on "deposits formed by concentration of substances" to the one on mesothermal deposits, and the shifting of the notes on Coro-Coro from the same chapter to that on deposits of native copper. Finally, the "index to mineral deposits by elements," in the old book, has been omitted. Wherever production and metal prices are mentioned, the figures have of course been brought up to recent date.

The documentation is excellent, and the author's command of the literature is so good that it is significant of the difficulty of now encompassing it all, that he knows little of Fourmarier's ideas, and does not mention George Haven Putnam's work on regional isostacy, nor the work of Foye on "stromatolithic" granite invasions. Nor does he realize that Airy did not conceive that his theory of roots of mountains required fusion or anything more than the plasticity found in the rock creep of mines.

The value of the book is increased by many maps and sections. These are frequently reproduced by photograph, as the original German or other foreign lettering shows, and occasionally (for example, Fig. 85) the lettering calls for a reading glass. It is well indexed for subjects, localities, and authors. ALFRED C. LANE.

Crustal Changes

THE DEFORMATION OF THE EARTH'S CRUST. *By Walter H. Bucher. Princeton University Press. Pp. 531; 100 figures. Price $5.*

This book is an attempt to gather into general statements called "laws" all essential facts that indicate the sources of crustal deformation-mountain building. These 46 laws are all grouped in an appendix (pp. 490-496). Besides, there are italicized in the text, and grouped in the index, 39 "opinions." The "laws," as the author says, require further testing, except in so far as they are definitions or statements of logical necessity, like Law 1, that deflections from the ellipsoid are either up or down. These he divides into swells and basins, non-linear, and welts and furrows, linear. The cause of these he finds more likely to be internal than external, mountain-building movements occurring in brief (p. 384) episodes, of which he gives a valuable table (p. 412) between long periods of rest.

Though he gives the literature and point of view of others, he does not favor either Wegener's theory of drifting, or Airy's of floating continents; nor does he consider isostatic readjustments creative of mountain building—only modifying. He looks (p. 477) to tensile and compressive stresses caused by alternating swelling and sinking of subcrustal matter due to fluctuations in the heat content of this asthenosphere as fundamental. Thus, he is of the school of Stille and Fourmarier. Nevertheless, with fairness he formulates in some of his laws (for example p. 101) some of the facts on which rival theories rest.

The division of the text and the use of different types are highly praiseworthy and should make this a first-rate text for students as well as a valuable book for the older geologist.

Publications Received

Tanganyika Territory Geological Survey Annual Report, 1932. Dar es Salaam. Pp. 40. Price 2s. 12d.

Should We Turn to Silver? By Herbert M. Bratter. Public Policy Pamphlets, No. 6, of the University of Chicago Press.

Seventh Annual Report of the Council for Scientific and Industrial Research for the Year Ended June 30, 1933. Canberra: The Government of the Commonwealth of Australia. Price 3s. 8d.

Mining and Metallurgical Investigations under the auspices of the Carnegie Institute of Technology and Mining and Metallurgical Advisory Boards. Reports, papers, and discussions presented at the seventh open meeting of the Metallurgical Board.

Annual Report (1933) of the Director of the Mint. The sixty-first annual report of the Director of the Mint, with a statement of the production and consumption of the precious metals in the United States for the calendar year 1932. Pp. 113. For sale by the Superintendent of Documents, Washington, D. C. Price 75c. (cloth).

The Prospector's Handbook. By W. L. Goodwin. Published by Industrial and Educational Publishing Company, Gardenvale, Quebec, Canada. Pp. 367. The third edition of a work that has had wide usefulness, particularly among Canadian prospectors, since it was first published in 1923. Price $3, postpaid.

Markenbezeichnungen in Feuerfest-Fach und im Ofenbau. By L. Litinsky, Leipzig. Published by the author. Pp. 98. Price, 6 Rm. An alphabetical index of about 1,500 of the best-known refractories and construction materials for furnaces, with properties and addresses of manufacturers. The volume also contains a bibliography on industrial furnaces.

Schwefel, Graphit, Jod, Bor, Magnesit, Talk. By O. Stutzer, W. Wetzel, and A. Himmelbauer. Gebrüder Borntraeger, Berlin. Pp. 396. Price, 32 Rm. The fifth volume of O. Stutzer's comprehensive handbook on the deposits of sulphur, graphite, iodine, boron, magnesite, and talc. Brief discussions of the mining and treatment of these minerals have also been included.

INDUSTRIAL PROGRESS

New Diaphragm Pump

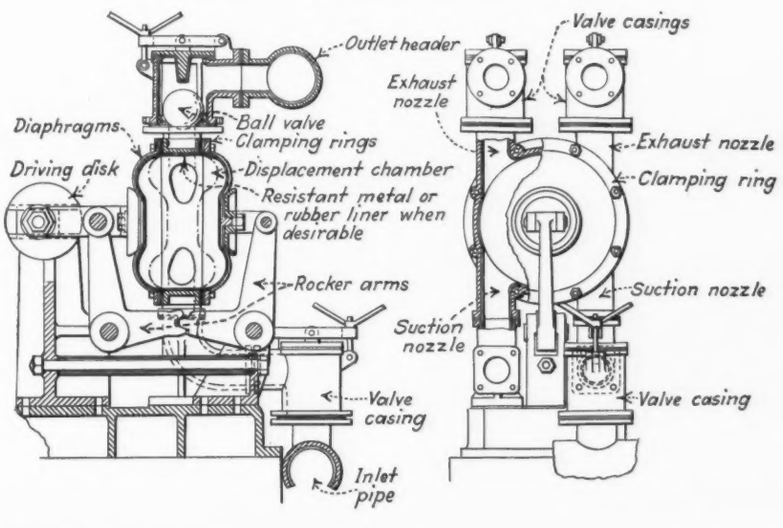
Design Said to Give Higher Efficiency and Longer Life In Handling Abrasive and Corrosive Materials

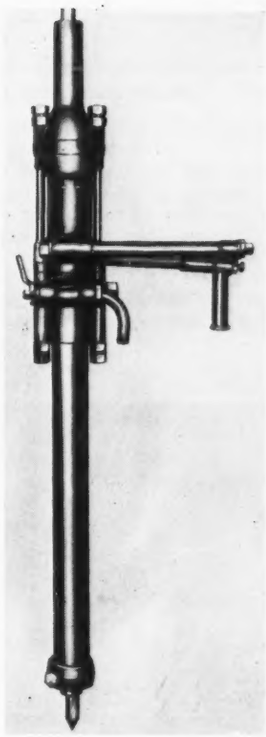
M. R. Hull, of Anaconda, Mont., has been granted a United States patent (No. 1,893,776) on a diaphragm pump of new design. This is especially intended for use in plants where highly abrasive or corrosive materials and liquids must be pumped. According to Mr. Hull, low efficiencies and high operating costs are tolerated to a greater extent ordinarily in the pumps used for such work than in any other mechanical equipment the plant may have. For such service, the inventor declares, the centrifugal-type pump is far from satisfactory because of rapid wear of the impeller and the liners and its extremely low efficiency. When one of these pumps is used for handling many of the corrosive solutions, the packing is a source of constant annoyance and expense. Their efficiency, moreover, for such work is low even when they are new and decreases quickly with wear. In certain severe service the life of impellers is very short and the yearly maintenance cost may exceed the cost of a new pump. To this cost must be added that of delays. Spare units must be installed if operation is to be continuous.

The diaphragm pump as ordinarily constructed has a very low capacity per unit of floor space, and its diaphragms are short-lived because of the distortion to which they are subject at every stroke. Such defects are overcome in the new pump, according to Mr. Hull. The general features of its design are shown in the accompanying drawings. The following advantages are claimed: (1) It has no stuffing box. (2) Compared to other diaphragm pumps, it has greater capacity per unit of floor space because its displacement chamber has two diaphragms instead of one and because the design is compact. (3) Parts are easily accessible. (4) For pumping abrasive sludges all parts in contact with the sludge may be rubber-lined. No moving parts except the diaphragms and valve balls touch the sludge. (5) No leakage nor splash occurs. (6) The diaphragm-operating mechanism is simple and the movement of the rocker arms so slight that their long life is assured. (7) The curved dotted lines in the vertical section of the accompanying drawing show the innermost, and the full lines the outermost, position of the diaphragms. The direction of curvature does not reverse during operation and the amount of movement near the clamp rings is practically zero. (8) To permit the quick removal of foreign objects, the valves are so made that the chamber cover may be swung back quickly and the valve cage and ball removed and replaced without use of any tool. Likewise, when necessary, the valve seat may be removed without removing a nut or bolt. Suction and discharge valves may be made interchangeable.

According to Mr. Hull, this pump can be run successfully against higher pressures than have hitherto been possible with diaphragm pumps. An additional feature is that little, if any, of the machining operations required in making the pump would be classed as precision work.

Vertical section and sectional end of double-diaphragm pump, invented by M. R. Hull, Anaconda, Mont.



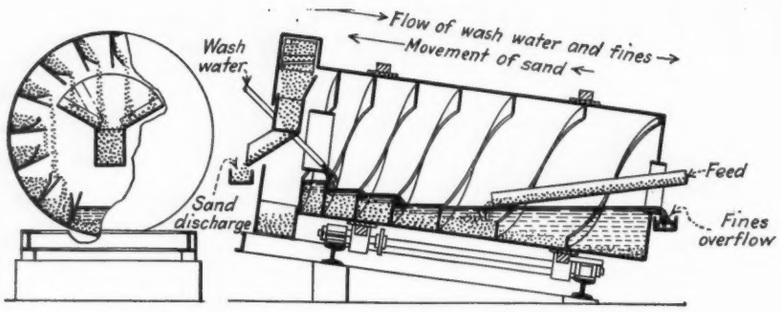


Durable Stoper Drill

A new stoper for general mine work in hard rock has been developed by Ingersoll-Rand. It is known as the N79 Stopehamer. It weighs 99 lb., is 54½ in. long with the feed closed and 76¼ in. with feed extended, has a 2½-in. air feed, and takes ⅞- or 1-in. solid hexagon or quarter-octagon steel. Features of design include: use of air pressure to keep cuttings out of front head; full air-cushioning of piston, eliminating need for springs; use of flapper valve to give high drilling speed; location of automatic lubricator and air-feed control button in rotating handle; and various details to insure durability and ease of handling.

Countercurrent Classifier

For separating relatively coarse from fine particles in a liquor classifying medium the Hardinge Company, York, Pa., has devised the so-called countercurrent classifier shown in the illustration. This is a slowly rotating drum having a screw flight on its inner surface. Material to be classified is fed in at one end above the pulp level, and as the classifier rotates, the coarse particles that settle out are moved forward by the screw flight, turning over and releasing any fines mixed with the coarse particles. The fines are washed back toward the overflow end by the wash water introduced at the sand-discharge end, and, with this wash water, overflow through an

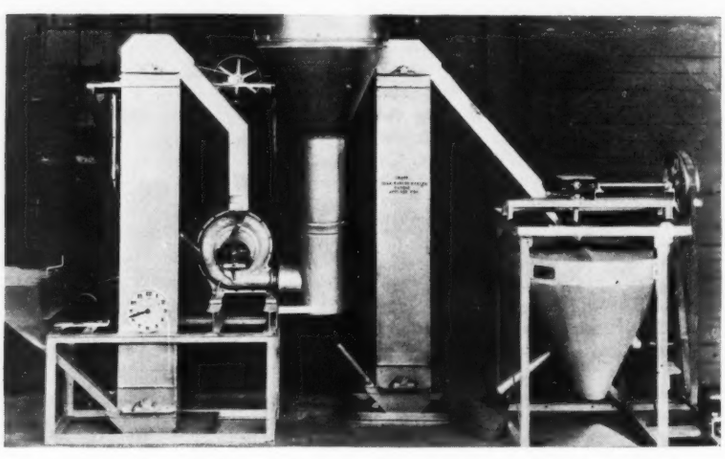


General features of countercurrent classifier and its operation

opening at the feed end. Sand or oversize, in moving to the opposite end, is dewatered and elevated to a higher elevation, so that the classifier may be operated in closed circuit with any suitable type of grinding mill without use of auxiliary equipment. Only one moving part is in contact with the pulp.

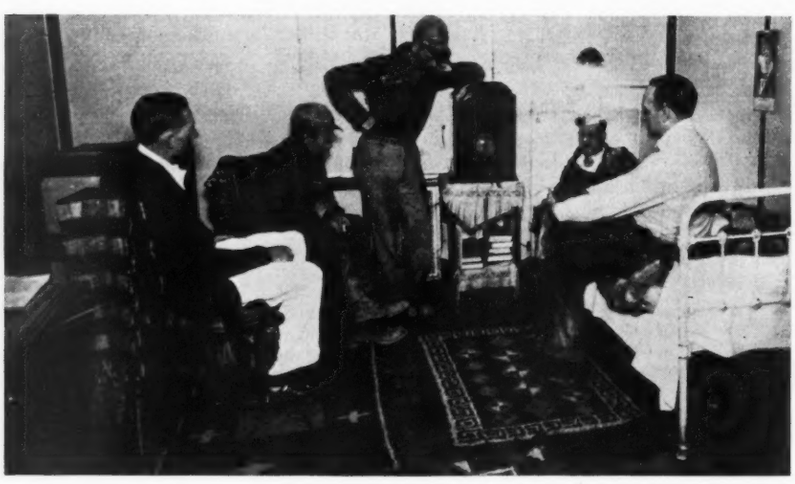
Another Dry Gold Concentrator

A. E. Grapp, president and chief engineer of the Despatch Oven Company, Minneapolis, has devised a machine for recovering gold from sand and gravel by dry treatment. Claim is made that fine gold is recovered. The machine (below) includes an attrition mill followed by a series of pans, one over the other, each having a set of revolving arms which propel the lighter materials toward the periphery and out of the pan and the heavier material toward a continuous center discharge. A pan will handle 2 cu.yd. of sand per hour. The concentrate is sacked for shipment.



The Radio in a Mining Camp Abroad

Combination of Station W2XAF, General Electric's short-wave transmitter with its reflector antenna pointed to the south, and one of the new G-E all-wave receivers, is said to have solved the problem of entertainment from home for American engineers in a Chilean mining camp. The men report that the Schenectady station is heard as easily as any of the South American broadcasting stations. A group listening to one of these sets is seen in the illustration.



Speed Reducer Units

Single-reduction units for ratios up to 6:1 inclusive have been added to its line of Gearmotors by the Reliance Electric & Engineering Company, Cleveland, Ohio. These can be furnished with both a.-c. and d.-c. motors of various types in sizes rated ¾ hp. and up. Multi-speed and adjustable-speed motors may be used. The entire reduction is obtained in a single pair of gears.

Industrial Notes

R. K. Stockwell, of the Robins Belt Conveying Co., is at present on an extended trip in Russia.

American Cyanamid Co. and American Cyanamid & Chemical Corporation announce that on and after April 16 their New York City address and that of their subsidiaries will be 30 Rockefeller Plaza.

Bulletins

Stainless Steel Castings. Edgar Allen & Co., Ltd. Imperial Steel Works, Sheffield 9, England. Folder, 8 pp. Also a separate folder on pins and bushes, 8 pp. Also a wall chart containing steel selection and treatment tables.

Merrill-Crowe Precipitation Process. Merrill Co., San Francisco. Folder, 6 pp.

Spot and Projection Welding Equipment. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Leaflet, 4 pp.

Power Pumps. Worthington Pump & Machinery Corporation, Harrison, N. J. Leaflet, 4 pp., on vertical triplex single-acting units, equipped with Worthington Multi-V drive. Also a leaflet on rotary pumps.

Armco Multi Plate. Armco Culvert Manufacturers Association, Middletown, Ohio. Folder, 6 pp.

Machinery for Complete Crushing Plants. Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Bulletin 1473, pp. 28.

Cameron Motorpumps. Ingersoll-Rand Co., New York. Catalog 7464, pp. 16, covering complete line of 26 sizes ranging from ¼ to 30 hp. and from 5 to 1,000 g.p.m. capacity.

Insulation in Non-Ferrous Metal Industries. Johns-Manville, New York. Book, 72 pp., describing insulation methods for roasters, furnaces, flues, boilers, and other heated equipment.

Mining Equipment. Demag A.G., Duisburg, Germany. Pamphlet 6214b, entitled "Up-to-date Mining Equipment Above and Below Ground." This describes the company's share in the development and supply of mining equipment during the last 75 years.

Centrifugal Pumps. Morris Machine Works, Baldwinsville, N. Y. Bulletin 152, pp. 20, on double-suction, horizontally split units.

Bracket-Bearing Synchronous Motors. Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Bulletin 1165, pp. 14.

Detachable Bits. Ingersoll-Rand Co., New York. Folder on Jackbits.

Lathes. South Bend Lathe Works, South Bend, Ind. Catalog 94, pp. 74.

Magnet Wire. General Cable Corporation, New York. Catalog, pp. 32. Also a pamphlet on installing Trenchlay nonmetallic sheathed cable.

Daily and Average Monthly Prices of Metals

March, 1934

United States Market

1934 Mar	Electrolytic Copper Domestic	Electrolytic Copper Export	Straits Tin New York	Lead New York	Lead St. Louis	Zinc St. Louis
1	7.775	7.800	52.275	4.00	3.90	4.400
2	7.775	7.800	52.450	4.00	3.90	4.400
3	7.775	7.825	52.450	4.00	3.90	4.400
5	7.775	7.800	52.500	4.00	3.90	4.400
6	7.775	7.850	52.525	4.00	3.90	4.400
7	7.775	7.850	52.600	4.00	3.90	4.400
8	7.775	7.825	53.200	4.00	3.90	4.400
9	7.775	7.850	53.625	4.00	3.90	4.400
10	7.775	7.875	53.650	4.00	3.90	4.375@4.400
12	7.775	7.875	54.200	4.00	3.90	4.375@4.400
13	7.775	7.925	54.250	4.00	3.90	4.375@4.400
14	7.775	7.925	54.100	4.00	3.90	3.375@4.400
15	7.775	7.850	54.000	4.00	3.90	4.375@4.400
16	7.775	7.825	53.825	4.00	3.90	4.375
17	7.775	7.875	53.750	4.00	3.90	4.375
19	7.775	7.750	53.625	4.00	3.90	4.375
20	7.775	7.750	54.125	4.00	3.90	4.375
21	7.775	7.800	54.000	4.00	3.90	4.375
22	7.775	7.825	54.150	4.00	3.90	4.350
23	7.775	7.825	54.375	4.00	3.90	4.350
24	7.775	7.850	54.300	4.00	3.90	4.350
26	7.775	7.850	54.600	4.00	3.90	4.325@4.350
27	7.775	7.850	54.450	4.00	3.90	4.325
28	7.775	7.800	54.650	4.00	3.90	4.300
29	7.775	7.850	55.150	4.00	3.90	4.300
30	7.775	7.850	55.350	4.00	3.90	4.300
31	7.775	7.850	55.450	4.00	3.90	4.300
For month Average	7.775	7.837	53.838	4.00	3.90	4.368
Averages for Week						
7	7.775	7.821	52.467	4.00	3.90	4.400
14	7.775	7.879	53.838	4.00	3.90	4.392
21	7.775	7.808	53.888	4.00	3.90	4.377
28	7.775	7.833	54.421	4.00	3.90	4.335
Calendar Week Averages						
3	7.775	7.815	52.267	4.00	3.90	4.399
10	7.775	7.842	53.017	4.00	3.90	4.398
17	7.775	7.879	54.021	4.00	3.90	4.383
24	7.775	7.800	54.096	4.00	3.90	4.363
31	7.775	7.842	54.942	4.00	3.90	4.310

Silver, Gold, and Sterling Exchange New York and London

1934 Mar.	Sterling Exchange "Checks"	Sterling Exchange "90-Day Demand"	Silver (a) New York	Silver (a) London	Gold London	Gold (b) United States
1	5.07250	5.07750	46.2500	20.5625	137s 1 d	$35.00
2	5.07375	5.07750	46.2500	20.5000	136s 7 d	35.00
3	5.07250	5.07500	46.3750	20.5000	136s10½d	35.00
5	5.07000	5.07000	46.2500	20.6250	136s10 d	35.00
6	5.06375	5.06625	46.2500	20.5625	137s 2 d	35.00
7	5.07500	5.07750	46.0000	20.3750	136s10 d	35.00
8	5.08000	5.08125	46.1250	20.4375	136s 8 d	35.00
9	5.07125	5.07000	46.2500	20.2500	136s10 d	35.00
10	5.07625	5.07625	46.2500	20.5000	136s10½d	35.00
12	5.08000	5.08125	46.7500	20.7500	136s10 d	35.00
13	5.09000	5.09250	46.7500	20.6250	136s 3½d	35.00
14	5.09750	5.10000	46.7500	20.6250	136s 2 d	35.00
15	5.09625	5.09875	45.8750	20.6250	136s 4 d	35.00
16	5.08750	5.09000	45.5000	20.0625	136s 5 d	35.00
17	5.09125	5.09375	45.7500	20.2500	136s 6 d	35.00
19	5.09000	5.09125	45.1250	19.8750	136s 6 d	35.00
20	5.11250	5.11250	45.7500	20.1875	136s 2 d	35.00
21	5.10875	5.11000	45.2500	19.9375	136s	35.00
22	5.11000	5.11125	45.2500	19.8750	136s 2 d	35.00
23	5.10375	5.10500	45.3750	20.0000	136s	35.00
24	5.09250	5.09500	45.6250	20.0000	136s 3 d	35.00
26	5.09625	5.09750	45.6250	20.0000	136s 5 d	35.00
27	5.09625	5.09750	45.3750	20.0000	136s 3½d	35.00
28	5.10250	5.10375	45.3750	19.8750	136s 3 d	35.00
29	5.13250	5.13500	45.5000	19.9375	135s 5½d	35.00
30	5.12750	5.13000	45.5000	.....	.....	.....
31	5.13000	5.13250	45.5000	.....	.....	.....
Av. for month	5.09259	.....	45.875	20.278	.....	35.00
Averages for Week						
7	5.07125	.....	46.229	.....	.....	.....
14	5.08250	.....	46.479	.....	.....	.....
21	5.09771	.....	45.542	.....	.....	.....
28	5.10021	.....	45.438	.....	.....	.....

Calendar week averages: New York Silver, Mar. 3, 46.146; Mar. 10, 46.188; Mar. 17, 46.229; Mar. 24, 45.396; Mar. 31, 45.479.

(a) Silver not eligible] for sale to the U. S. Government. Under Executive order issued Dec. 31, 1933, the U. S. Government price on newly mined domestic silver was established at 64¼c. per troy ounce.

(b) U. S. Treasury's gold price.

London Market

1934 Mar.	Copper Standard Spot	Copper Standard 3 Mo.	Copper Electrolytic Bid	Standard Tin Spot	Standard Tin 3 Mo.	Lead Spot	Lead 3 Mo.	Zinc Spot	Zinc 3 Mo.
1	32.5625	32.6875	35.6250	228.5000	227.8750	11.3750	11.6250	14.4375	14.8125
2	32.4375	32.6875	35.6250	229.1250	228.3750	11.5000	11.8750	14.6250	14.9375
5	32.7500	33.0000	35.5000	229.6250	228.3750	11.6250	11.9375	14.6875	15.0625
6	32.8125	33.0625	35.5000	229.8750	228.5000	11.6875	12.0625	14.8750	15.2500
7	32.7500	32.9375	35.7500	229.6250	228.6250	11.5625	11.9375	14.7500	15.0625
8	32.6250	32.8750	35.5000	230.8750	229.8750	11.5000	11.8750	14.7500	15.1875
9	32.8125	32.9375	35.7500	233.2500	231.7500	11.2500	11.6250	14.7500	15.1250
12	33.1875	33.4375	36.0000	234.2500	233.3750	11.5625	11.8750	14.7500	15.1250
13	33.1250	33.3125	36.0000	236.2500	234.5000	11.7500	12.0000	14.7500	15.1250
14	32.7500	33.0000	36.0000	236.0000	234.3750	11.6250	11.8750	14.7500	15.1250
15	32.2500	32.4375	35.5000	234.3750	233.0000	11.5625	11.8750	14.7500	15.0000
16	32.5000	32.6875	35.5000	234.2500	233.2500	11.6250	11.8750	14.6250	14.8125
19	31.6875	31.9375	34.7500	232.7500	231.6250	11.4375	11.6875	14.5625	14.8125
20	32.1250	32.3125	35.0000	234.3750	232.7500	11.3750	11.6875	14.6250	14.8750
21	32.1875	32.4375	35.2500	234.7500	233.2500	11.3750	11.6875	14.6875	14.9375
22	32.2500	32.5000	35.2500	234.8750	233.3750	11.5000	11.7500	14.6875	14.9375
23	32.5625	32.7500	35.5000	236.0000	234.6250	11.6250	11.8750	14.7500	15.0000
26	32.3125	32.5625	35.5000	237.3750	235.2500	11.6250	11.8750	14.7500	15.0000
27	32.5000	32.6875	35.5000	238.8750	236.8750	11.6250	11.8750	14.8750	15.1250
28	32.0000	32.3125	35.2500	237.5000	236.1250	11.6250	11.8750	14.8750	15.1250
29	32.2500	32.5625	35.5000	238.6250	237.0000	11.6250	11.8125	15.1250	15.2500
30					Holiday				
Av. for month..	32.497	.....	35.512	233.863	.....	11.545	11.836	14.735	15.033

The United States quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices of domestic class are in cents per pound.

Copper, lead and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted as 0.35c. per pound above St. Louis, this being the freight differential. Contract prices for High-Grade zinc delivered in the East and Middle West usually command a pre-

Silver and Sterling Exchange

	New York		London Spot		Sterling Exchange	
	1933	1934	1933	1934	1933	1934
January	25.400	44.188	16.883	19.382	336.060	504.644
February	26.074	45.233	16.885	20.073	342.114	503.085
March	27.928	45.875	17.588	20.278	343.138	509.259
April	30.730		18.440		357.565	
May	34.072		19.046		393.106	
June	35.663		19.078		413.216	
July	37.630		18.341		464.760	
August	36.074		17.877		449.944	
September	38.440		18.272		466.240	
October	38.190		18.221		466.380	
November	42.974		18.428		514.573	
December	43.550		18.674		511.260	
Year	34.727		18.144		421.530	

New York quotations for silver not eligible for sale to U. S. Government, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery			London Spot			
	Electrolytic			Standard		Electrolytic	
	Domestic		Export				
	1933	1934	1934	1933	1934	1933	1934
January	4.775	7.890	7.831	28.557	32.560	33.244	35.614
February	4.775	7.777	7.844	28.481	33.072	32.556	35.969
March	5.011	7.775	7.837	28.179	32.497	32.370	35.512
April	5.395			29.576		33.681	
May	6.698			34.071		38.163	
June	7.773			36.759		41.000	
July	8.635			37.917		41.524	
August	8.768			36.071		40.227	
September	8.753			35.122		38.339	
October	7.950			33.656		36.977	
November	7.881			30.588		33.898	
December	7.885			31.306		34.329	
Year	7.025			32.524		36.359	

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1933	1934	1933	1934	1933 Spot	1933 3 Mos.	1934 Spot	1934 3 Mos.
January	3.000	4.000	2.875	3.900	10.458	10.833	11.304	11.517
February	3.000	4.000	2.875	3.900	10.431	10.719	11.634	11.913
March	3.146	4.000	3.021	3.900	10.609	10.821	11.545	11.836
April	3.260		3.135		10.872	11.122		
May	3.654		3.525		12.095	12.372		
June	4.173		4.023		13.280	13 571		
July	4.452		4.303		13.411	13.613		
August	4.500		4.350		12.182	12.457		
September	4.500		4.350		11.932	12.229		
October	4.313		4.176		11.804	12.102		
November	4.288		4.146		11.537	11.778		
December	4.141		4.042		11.431	11.658		
Year	3.869		3.735		11.670	11.940		

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin

	New York		London	
	1933	1934	1933	1934
	Straits		Standard, Spot	
January	22.692	51.891	145.708	226.631
February	23.500	51.668	148.544	226.731
March	24.221	53.838	149.120	233.863
April	27.136		157.944	
May	36.051		186.207	
June	44.097		219.964	
July	46.356		216.673	
August	44.794		215.210	
September	46.665		216.893	
October	47.858		223.455	
November	53.011		226.722	
December	52.936		227.678	
Year	39.110		194.510	

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1933	1934	1933 Spot	1933 3 Mos.	1934 Spot	1934 3 Mos
January	3.018	4.271	14.381	14.595	14.688	14.943
February	2.666	4.384	13.866	14.119	14.844	15.125
March	2.987	4.368	14.647	14.674	14.735	15.033
April	3.298		14.951	15.208		
May	3.805		15.505	15.660		
June	4.348		16.988	16.774		
July	4.878		17.795	17.789		
August	4.916		16.869	17.031		
September	4.699		16.810	17.042		
October	4.748		16.310	16.599		
November	4.520		15.048	15.349		
December	4.461		14.826	15.059		
Year	4.029		15.666	15.825		

St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1933	1934	1933	1934
January	55.000	55.000	23.300	23.300
February	55.000	55.000	23.300	23.300
March	55.000	55.000	23.300	23.300
April	55.000		23.300	
May	55.000		23.300	
June	55.000		23.300	
July	55.000		23.300	
August	55.000		23.300	
September	55.000		23.300	
October	55.000		23.300	
November	55.000		23.300	
December	55.000		23.300	
Year	55.000		23.300	

Aluminum in cents per pound, 99 per cent grade.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1933	1934	1933	1934	1933	1934
January	5.722	7.198	48.500	67.538	26.480	38.000
February	5.738	7.172	48.614	72.011	24.000	38.000
March	5.901	7.545	52.676	75.472	24.667	38.000
April	5.876		54.580		26.800	
May	6.264		56.500		28.500	
June	6.500		60.038		30.000	
July	7.262		62.900		32.320	
August	6.986		63.500		33.000	
September	6.880		64.580		34.560	
October	6.843		66.500		36.000	
November	7.113		66.000		37.583	
December	7.250		66.330		38.000	
Year	6.528		59.227		30.993	

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce troy.

Pig Iron

	Bessemer		Basic		No. 2 Foundry	
	1933	1934	1933	1934	1933	1934
January	14.50	18.00	14.00	17.00	14.50	17.50
February	14.50	18.00	14.00	17.00	14.50	17.50
March	14 50	18.00	14.00	17.00	14.50	17.50
April	14.50		14.00		14.50	
May	15.42		14.42		14.92	
June	16.00		15.00		15.50	
July	16.50		15.50		16.00	
August	17.00		16.00		16.50	
September	18 00		17.00		17.50	
October	18.00		17.00		17.50	
November	18.00		17.00		17.50	
December	18.00		17.00		17.50	
Year	16.24		15.41		15.91	

Iron in dollars per long ton. F.o.b. Mahoning and Shenango Valley furnaces

mium of 1c. over Prime Western zinc.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London prices for lead and zinc are the official prices for the first session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

New York silver quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, 925 fine Sterling prices represent noon market demand.